

The Black Box Theater and AV/IT Convergence:

# CREATING THE CLASSROOM OF THE FUTURE

By Mark S. Valenti

Most classrooms being designed today look very much like classrooms designed one hundred years ago. Though the scope and scale of today's classroom building far exceeds that of yesterday's one-room schoolhouse, a teacher from 1902 would likely adapt rather quickly to the classroom of 2002, once he or she could locate the chalk.

Classrooms are still primarily a venue for lecture, although today it is mostly a technology-enhanced lecture. Over the past decade, higher education institutions have focused on a classroom technology complement that includes a computer, a network connection, and some degree of audiovisual presentation, three components that in concert provide the instructor with a powerful set of tools—for lecture. This is a process in progress. Many colleges and universities are still hard at work building basic lecture-presentation systems. Many teachers are still hard at work developing the materials they need in such an environment. Many students, meanwhile, have moved well beyond the entire lecture concept.

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Once the use of digital content becomes commonplace in the classroom, it is a logical and relatively easy next step to make those materials available to students on the campus network. Many instructors recognized this early on and started making class materials accessible via the Web. Today entire programs have begun to supplement class materials with audio and video recordings of the lectures that compose a course. Sometimes those signals are delivered in real time to remote students and are also stored for retrieval by students both on and off campus for subsequent review. At least one university is creating a new college that is deliberately doing away with large lecture sections for classes such as Introductory Chemistry and is using interactive, Web-based software in place of routine, three-hundred-student lectures.<sup>1</sup>





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The classroom, once the domain of the professional lecturer, is fast becoming a multimedia-intensive, highly collaborative facility used to produce and consume media-rich materials. Today's students are adept at manipulating digital media of all types, and it's not an unreasonable leap to imagine students extracting the chunks of audio, video, and graphics that are most relevant to their interests or needs in order to develop an understanding of the requisite course concepts. It's another short hop to imagine those chunks being shared among members of an informal work group, or learning community, that has formed to help participants navigate the course together. (At another level, there is much activity in the development of learning objects, which can be viewed as professionally developed "chunks" of content.) Back in the classroom, it is easy to imagine students retrieving their work for display and discussion with fellow students and the instructor. In fact, it is useful to think of both teacher and student in this setting as "prosumers." This is a made-up word, but it can begin to shape our perceptions of the activities that occur in the classroom and subsequently of the criteria that are used to plan, program, and design new, flexible, technology-enabled learning spaces.

### The Technology-Enabled Classroom

Currently, most college and university classroom planning begins with an analysis of contact hours, utilization rates, and station sizes. The formulas used to develop a statement of need are some years old now, and are a good place to begin, but most planning professionals acknowledge that an update is long overdue.<sup>2</sup> Demand for flexibility, a new understanding about ergonomics, and technological advances are but a few of the factors rendering the old formulas obsolete.

One way that technology affects the classroom is the sightline requirement to accommodate digital projection. Research into human visual perception has resulted in clearly defined limits for nearest

viewer and farthest viewer, limits that are directly related to image height.<sup>3</sup> In a typical twenty-five-seat classroom with a screen and projector, this factor can render the first third of the room unusable for student seating: these seats are simply too close to the image. (It's important to note that the design criteria for display size in education are different from those for display size in entertainment, as are the criteria for computer graphics as opposed to video.) One outcome is that the station size gets larger. It is not uncommon today to find allocations of twenty-five to forty square feet per student, where previously fifteen square feet was the norm.

Another factor to consider, as faculty become both adept at and accustomed to using presentation technology, is that one image is not sufficient. First-generation technology classrooms have single screens. Second- and third-generation rooms typically have two or more screens/images. This places an even greater demand on "real estate" at the front of the room, again leaving less room for student seating. Often a second-generation room provides digital annotation in lieu of a chalkboard or whiteboard not only because instructors are accustomed to working with digital course materials and are comfortable with the tools but also because there is simply not enough room at the front of the classroom to accommodate a traditional writing surface.

Lighting is another classroom component that takes on new importance. As the functions of a classroom evolve from passive to active learning, new zones of activity emerge. To support these zones, a flexible lighting solution is required. The lighting solution will also have a direct bearing on the design and implementation of the presentation system, since the light output of the projector must be determined in the context of the ambient light in the room. It is essential to provide sufficient foot-candles at the desktop for note-taking during presentation, sufficient foot-candles and proper color temperature for video capture, and a user-

friendly, convenient control solution so that room functions can change effortlessly. It is also essential to design horizontal foot-candles to accommodate cameras. Contemporary classrooms often provide three or four presets for the instructor. To meet these needs, a new category of professional lighting instruments has emerged in the past decade, with specially designed fluorescent lamps for low heat gain and energy usage and with appropriate color temperature for video recording. Of course, in a classroom intended for two-way interactive video communications, lighting system requirements may be an order of magnitude greater to deliver higher production values.

As the classroom has become a multimedia communications environment, the importance of classroom acoustics has increased—along with a growing awareness of the impact of poor acoustics on student comprehension.<sup>4</sup> Audio recordings and communications have become commonplace in the classroom, either alone or as part of a video recording or two-way communications. Presentation systems typically include loudspeakers, and classrooms over a certain size are required to have speech-reinforcement systems.

There are three acoustical components to consider:

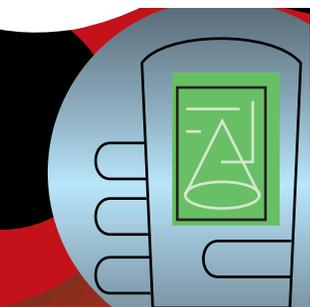
1. *Isolation between adjacent spaces.* Demand for long-term flexibility in the overall building often results in a construction methodology that uses metal studs and drywall for classroom walls. The architecture's design must properly isolate one classroom from another. Sound systems behave differently, with an extended frequency range and potentially greater loudness than the human voice. Walls must exhibit a higher transmission loss to effectively isolate adjacent spaces.
2. *Noise performance of the heating, ventilating, and air conditioning (HVAC) system.* HVAC noise has been shown to be the single greatest impediment to student

comprehension in the classroom and is extremely difficult to reduce once a system is in place.<sup>5</sup>

3. *Acoustical quality, which refers to the reverberant nature of the room.* Excessive reverberation can reduce speech intelligibility, thereby affecting a student's ability to hear and comprehend. It can

“black box” classroom provides the same kind of functions and supports a wide variety of teaching and learning styles. The concept first emerged in 1996, during the design of the “Global Classroom,” part of the new Science and Technology Building now under construction at East Carolina University, and has since been applied on

The audiovisual wave, which began in earnest with the development of low-cost LCD projectors in the mid-1990s, has not played out. Unlike telecommunications, personal computing, and data networking, the audiovisual component of the campus has not yet achieved respect as a mission-critical technology. That is changing



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also render a recording system useless due to a low signal-to-noise ratio. Conversely, insufficient reverberation can physically exhaust an instructor who is trying to project sufficiently over an extended period of time. A careful balance is required to accommodate a broad spectrum of uses.

Let's recap. We have described a facility that requires clear sightlines to a large display, the nature of which may change periodically and may occasionally change rapidly. The main focus for the audience is at the front, but the facility furnishings are flexible enough that the audience can participate interactively when necessary. The facility must ensure repeatability of conditions yet must change over time. There is need for a flexible lighting system that can be rapidly adjusted to suit the activity at hand and that is easy to set up and operate. And there is a fairly rigorous acoustical consideration: to be sure that the activities in the facility do not impose on neighbors; and to be sure that the message can be heard by the audience and can be recorded for future applications.

For those with an interest or background in the performing arts, this may sound like the description of a “black box” theater. A “black box” theater is one that is inherently flexible in that the relationship of audience to stage can take on any configuration required: traditional proscenium, thrust, or theater-in-the-round. The theater provides a built-in level of technology that can be adapted to the requirements of any performance, and turnover is easy and quick. A

projects at Western Kentucky University, Ohio State University, and Mott Community College in Michigan. The “black box” classroom features a simple lighting grid overhead with a small theater-type lighting package. Robotic cameras and self-contained displays are portable and easily reconfigured; wired network and power are available above the grid, in the floor, and around side walls. Wireless network is available throughout. Furnishings are flexible and easily rearranged at a moment's notice. Is this a trend in classroom design? Not quite, but as a model for the future, it deserves consideration, exploration, and further development. The “black box” classroom certainly provides both teacher and students with the tools and flexibility that are so essential today.

### The AV/IT Infrastructure

Underlying the concept of the “black box” classroom is the convergence of audiovisual and information technologies. This is an emerging trend with long-term consequences for colleges and universities and is a key reason why many students have moved beyond the basic lecture-presentation classroom model. To manipulate audio and video content, specialized software applications running on high-powered, expensive workstations were the norm as little as six or seven years ago. Today the same features are part of the package on consumer-grade workstations from Dell, Sony, Gateway, and others—sitting in the bedrooms of tomorrow's freshman class. This trend is not limited to the PC marketplace.

rapidly, however, because in the classroom of the future, audiovisual tools coupled with reliable, high-performance networking will be essential. New developments in audio, video, digital broadcasting, and systems control, along with continuing advances in optical and wireless networking, point to a media-rich future. Setting the stage is the technology writer Michael Malone's observation that “unlike the World Wide Web, the Great Global Grid will be a primarily visual medium.”<sup>6</sup>

In many ways, the audio industry is the bellwether for technological advancement. It was the audio industry that developed the compact disc, a data-storage standard that continues to evolve. In February 2002 a consortium of manufacturers announced yet another generation. The “Blu-Ray” disc is able to store a couple of hours of HDTV and six times that of standard video. Of course, every college and university CIO spent a pile of money and man-hours throughout the latter part of the 1990s strengthening the campus network to enable students to access multimedia curriculum resources, only to have the lowly MP3 file bring the network to its knees—daily! So audio has also brought us an awareness of the power of peer-to-peer computing and a need to shore up encryption and security technologies to protect valuable intellectual assets.

From a systems perspective, low-cost digital signal processing (DSP) technology has revolutionized the design of audio systems, from recording and post-production to sound reinforcement. Today, sophisticated multipurpose rooms

feature powerful, flexible sound systems that support speech, live music, and pre-recorded surround-sound. When the user selects the desired mode, the system configures itself to provide appropriate frequency response, temporal relationships, and power allocations, and it performs routine self-analysis to ensure that all components are active and working properly. Many of these functions today occur on dedicated networks optimized for audio performance, but the movement toward an IP-addressable environment is clear.

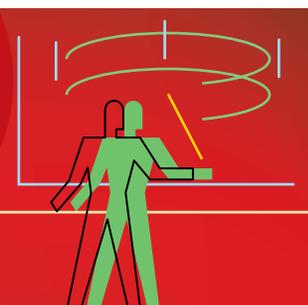
Speech recognition is only just making its voice heard (sorry!) but will soon influence audiovisual system design in a significant way. In planning and design meetings, the application of speech recognition to

ensure the reliability of the network for those aspects critical to life safety (e.g., 911 and other emergency communication functions). Such attributes were not required for "typical" data applications in the past. Advantages of VoIP include lower long-distance charges, increased business productivity, and the need to maintain only one network instead of two. For those involved in the planning and design of new facilities and the systems inside them, the cost savings in design and implementation of a single network are immediate and inherent.

In the visual realm, the fun is only just beginning. Although the broadcast industry's transition to digital television is well under way, most homes in the United

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One interesting and very telling phenomenon that has been occurring with increasing frequency is display requirements being described in terms of the number of pixels rather than lines of resolution in the image. Users want to display large data sets and to share those data sets with research partners elsewhere on the network. Are these display systems television, or videoconferencing, or distance learning, or collaborative computing? Yes! High-speed networks are enabling simultaneous, real-time sharing of high-resolution images, immense data sets, and



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user-control systems is being given serious consideration for projects destined to come online in three to four years. After all, we can already buy this component for our cars! Those involved in distance learning or e-learning have probably already been asked to investigate or implement technologies that convert speech to text to create searchable content databases. In fact, a number of excellent products have been on the market for several years and are maturing rapidly.

Telecommunications, perhaps the original audio business, is extremely turbulent right now, partially due to a shake-out of an industry that overbuilt but mostly due to a technology shift. Voice over IP (VoIP) technologies are rapidly gaining ground on legacy PBX-based systems. Institutions intending to expand telecommunications capacity to serve new buildings or campus growth must give VoIP due consideration today. VoIP places unique demands on the data network in terms of traffic management and latency, both of which affect quality of service. The use of VoIP also means the network must be designed with redundant power and other attributes that will

States are still using 4:3 analog display devices. Over the next few years, as consumers' sets age and the digital transition is completed, we can expect rapid advances in the merger of visual entertainment and communications services. Already established in the marketplace, consumer products such as TiVo enable viewers to time-shift scheduled television programming and eliminate advertising. Hypothetically speaking, a learning network could use off-hours streaming to a dedicated \$300 TiVo-type device capable of storing thirty hours of broadcast-quality video at any one time, delivering the "black box" classroom to the home.

Videoconferencing, long heralded, is finally emerging as a viable medium, not just because video technologies have improved but also because the necessary bandwidth to support high-quality video communications is finally in place. Many information technology managers are only now attempting to understand the implications of video on the network, as applications such as video streaming become commonplace. The media tools required to implement such an environment are becoming suffi-

ciently sophisticated and affordable that some institutions are making video capture and streaming a baseline functionality for new classroom design.

Another facet of a sophisticated, integrated AV/IT campus is a new set of control and systems-management tools. Chief among developments in this area are Web-based control technologies. Advantages include the ability to create a universal user-control interface for audiovisual systems across the institution and a significantly improved ability to manage audiovisual assets. A universal user-control interface lowers training and technical support costs and enhances usability of the audiovisual tools. An onboard tutorial (audiovisual, of course!) can require the first-time user to undergo basic training before proceeding with using the system. Updates, changes, or advanced training from a centrally administered, remote location might be handled as an in-house function or might be outsourced to a new,

emerging class of systems integrator. That same Web-based capability also enables the management of audiovisual assets in ways previously unavailable, but quite familiar, to the CIO. System usage patterns, individual device status, user access, and remote troubleshooting are examples of IT functions incorporated in the audiovisual environment. New organizational and financial models, such as combination AV/IT help desks and life-cycle funding analyses, are helping manage and maintain a complex technology base.

### What's Next?

What's just over the horizon? Next-generation technologies will be less overt and subtler. Computing power will move out of the box on our desks and into everything around us. Smart furniture, smart building products, and even smart clothing will change the way users interact with technology. The Internet as we know it today is going to submerge into the fabric of all that we do, carrying data generated by perhaps billions of IP-addressable "things," while a new class of network is emerging to carry audiovisual-rich communications to us wherever we are. It's likely that today's cell phone will become more of a "personal server" than a dedicated communications device. Students have already discovered that the

system for guest check-in and check-out. A guest need only walk in the hotel entrance with a cell phone. The hotel system recognizes the guest's cell phone and downloads the guest's room number. The guest approaches the room, and the door opens automatically. The guest walks into the room, and all personal preferences are set: temperature, lights, even the radio station!

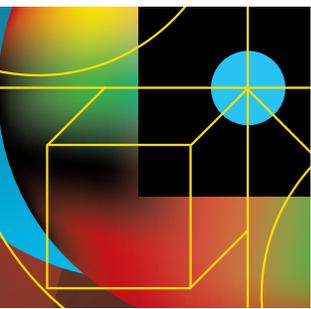
New, flexible, digital "wallpaper" will enable large-scale, high-resolution emissive displays, allowing the creation of a low-cost, immersive virtual-reality learning space—the next generation of classrooms beyond the "black box" model discussed here. At least one company is working on large-scale displays by focusing on nanotechnology.<sup>7</sup> The idea is to create a microscopic LCD element that can be embedded in a vinyl wall covering. The vinyl sheet carries the circuitry that connects the millions of individual display elements. Coupled with software applications now being developed to support collaborative research environments, this technology could result in a low-cost, immersive virtual-reality classroom even at the elementary-school level.

The following scenario illustrates the classroom of the future: An instructor enters classroom #104. As she does, the identification in her bracelet automatically connects to the Web-based control system,

capita consumption patterns over the past five decades. Across campus, in the network operations center, a technician glances up to see that room 104 has just gone online. All indicators are "green" as cameras, codecs, and disc arrays confirm operation. "Welcome to Econ 241 . . ." Twenty-two students in seven states scribble on digital tablets. Another forty will access the files within twenty-four hours.

### Perils and Plans

The technology-enabled classroom and the AV/IT infrastructure are affecting every facet of campus systems design, engineering, implementation, and operations. New technologies are enabling new applications as quickly as we can imagine them. The challenge is to anticipate the impact of these new technologies and understand how related areas such as staffing, organization, evaluation metrics, and operating costs are affected. This analysis can then serve as the basis for an informed design of systems and related infrastructure. The design of new campus educational and research facilities—including not only classrooms and laboratories but also student unions, recreational centers, and residence halls—has become extremely audiovisual-intensive, reflecting our culture's reliance on visual communications and entertainment. It is



## Smart furniture, smart building products, and even smart clothing will change the way users interact with technology.

Apple iPod, with its 5-GB or 10-GB drive, makes a very functional portable server, in addition to being a pretty cool MP3 player. Researchers at MIT, Carnegie Mellon, Georgia Tech, and Oregon State have created laboratories dedicated to wearable computing, and companies such as Xybernaut are marketing fully functional, wearable PCs.

Bluetooth and other wireless communications protocols will enable technology to anticipate users' needs. In 2001, for example, a hotel in San Francisco announced it was implementing a wireless

which immediately begins to configure the presentation system, network, and room fixtures to her preferences. By the time she sets her briefcase beside the desk, the surface display on the desk has her parameters set, the class Web site is online, and the lights, window treatments, and sound system are being adapted. Students settle in, adjusting heads-up displays and getting out their wireless pens. The instructor waves her hand over the display on the desk surface and turns to the front wall and to the image that appears there, a three-dimensional representation of per-

not unusual for the audiovisual technology budget to be \$2 to \$3 million for one academic building; \$1 million is quite ordinary today. To put that in perspective, outfitting the data network for the same building may cost \$500,000 and telecommunications about \$400 to \$500 per station. Imagining a successful long-term technology implementation without a cohesive, coordinated approach to data, voice, and visual communications is nearly impossible.

The problem today is the way new campus buildings are planned and financed.

Wherever the project originates—whether with the state board of regents or the college/university facilities group—most institutions do not adequately factor in the cost of a converged technology solution. Historically, data and telecommunications cabling is assumed to be part of the building, whereas audiovisual technologies are included as part of the FF&E budget (Furniture, Fixtures, and Equipment, for those of you lucky enough not to have been part of such a project). In this model, the FF&E budget often becomes the “contingency fund.”

This model presents numerous perils:

- Functionality and/or quality are pushed out of the solution.
- The classroom systems in the new building bear no resemblance to those in the building next door, completed only two years earlier.
- Some classrooms are fitted out, whereas others await equipment funding in two or three years.
- Instructors struggle with inconsistent user controls.
- Tech support personnel struggle with inconsistent solutions.
- The registrar struggles with classroom scheduling and with demands for “rooms that work.”

Enlightened institutions are beginning to recognize that without a cohesive technology plan and budget, campus facilities will not be effective teaching, learning, or research environments. A cohesive plan includes three steps:

1. *Organize.* The first step is to organize, under one roof, the responsibility for information technologies, communications technologies, and instructional technologies. For example, the classroom-support personnel and the desktop-support staff should be put in

the same room and held to the same performance standards. (Eventually, the two groups will be the same.) Data, telecom, and media distribution technologies should be colocated. (Eventually, they will run on the same equipment.) The facilities department should become a strategic partner of sorts to implement the building of the future. (Eventually, its buildings are going to run, literally, on the institutional network. Advances in building automation and other “typical” facilities systems such as power management and HVAC monitoring/control will soon—now!—require network infrastructure and bandwidth.)

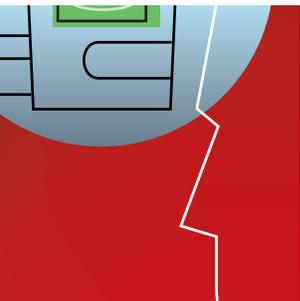
2. *Participate.* Those responsible for information technology should insist on a presence at the planning, design, and construction table. A project manager should be assigned with responsibility for the technology component of any project. Most campus facilities project managers will gladly accept the expertise and assistance. Most design consultants will also welcome the expertise and assistance. The opportunity to build consistency across multiple projects must be created; it won't just happen.
3. *Interface.* A standard user interface must be established for classroom technologies. The benefits are too many to list here. The banking industry can provide guidance. What banking has done with the automatic teller machine (ATM) as a universal user interface is nothing short of a miracle. Without such an interface, the ATM market would not exist. The same experts who developed the ATM interface are now the leading manufacturer of control systems for the classroom. A consistent user interface enhances usability, manageability, serviceability, and scalability of audiovisual systems. It almost cer-

tainly improves return on investment, although no comprehensive research seems to have been performed yet in the higher education marketplace.

The bottom line is that students know. They adapt readily and quickly to new technologies, and they increasingly vote with their feet. The campus technology environment plays a key decision-making role when students are selecting an institution. For some, it means “what's available in my dorm room?” For others, it's a matter of after-hours access to online learning. The contemporary college or university must be adept at teaching students both on and off campus, providing opportunities for learning on the students' terms. This translates into a flexible learning environment that slips easily between real and virtual learning spaces. Two keys to developing that kind of environment are a flexible, technology-enabled classroom and a comprehensive AV/IT infrastructure. The tools and expertise are in the marketplace. Creating the future requires simply commitment and clear vision. *e*

#### Notes

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7. Elizabeth Corcoran, “Out of This World,” *Forbes*, September 18, 2000.



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