DOWN THE DIGITAL DIRT ROADS: INCREASING DISTANCE LEARNING ACCESS WITH HYBRID AUDIOGRAPHICS

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ABSTRACT

Distance learning has the potential to enhance individual competency and military unit readiness by delivering learning where needed and when needed. However, this requires the distance learning systems to be highly accessible. Many potential classrooms, learners and organizations, especially those in the Reserve Components of the Armed Forces, don't have direct access to the Information Superhighway. Instead, they live down the equivalent of digital dirt roads. The proliferation of low cost personal computers capable of rendering high quality graphics, adoption of international standards for multimedia conferencing, ubiquity of Internet access and universal telephone service have created the opportunity to deliver scaleable, low cost multimedia instruction down the digital dirt roads with the hybrid audiographics approach. This approach delivers high quality audio over telephone lines and data interaction over packet switched Internet connections, thus distributing the transmission load between two highly accessible but limited bandwidth media. This paper explores the need for hybrid audiographics and describes a study comparing the performance of groups of Reserve Component soldiers taking an introductory course on Information Operations via the following modes: (1) hybrid audiographics, (2) hybrid audiographics with video of instructor and (3) traditional face to face classroom. The study results suggest there is no difference in student learning performance between the hybrid audiographics mode of instruction and the traditional classroom for the Information Operations course. The results also suggest video of the instructor had no effect on learning performance as measured by self assessment or actual test grades. Just as important, the typical transmission costs associated with delivering hybrid audiographics were calculated as approximately 4% of the cost of two-way full motion video using Defense Information System Agency services.

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INTRODUCTION

Distance learning is rapidly growing throughout industry, government and academia. It is widely recognized as the method of choice for reducing costs, increasing flexibility, increasing access and increasing number of learners reached. The potential for savings to the military services is tremendous, with the equivalent of over 170,000 student years of instruction provided annually in residence (Office of the Under Secretary of Defense for Personnel and Readiness, 1999).

Of greater importance is the potential of distance learning to increase unit readiness by providing critical training for individuals, crews and leaders as and where needed. This on-demand learning has the potential to dramatically enhance organizational performance by increasing personnel qualifications in the unit and reducing the impact of skill decay. The ability to conduct pre-deployment, mission specific training under the tutelage of skilled subject matter experts can result in faster preparation for contingencies.

Since distance learning by definition relies on technology for delivery (Sauve, 1993), there is also a challenge to provide service to areas and learners with limited access to technology. Distance learning has the power to level the playing field for Reserve Component and geographically remote organizations and learners by providing a learning experience without walls or barriers. In order to do this, distance learning technologies must go beyond the Information Superhighway on-ramps to reach learners down the two lane streets and digital dirt roads. The more courseware designers and program managers rely on high cost, high bandwidth, exotic equipment and dedicated facilities, the more difficulty in reaching the units and learners who can benefit the most from distance learning. To traverse these digital dirt roads, distance learning must embrace scalability, use common infrastructure and provide effective learning. It must be also be affordable and available.

INFORMATION SUPERHIGHWAY

The Department of Defense's vision is to harness the power of the Information Superhighway in the form of the Internet and other virtual or private wide-area networks (WANs) to deliver effective learning (Office of the Under Secretary of Defense for Personnel and Readiness, 1999).

The Information Superhighway is a system of high-speed connections sending huge volumes of electronic data throughout the world at the speed of light. This network of networks is revolutionizing our entire society through unprecedented access to tailored knowledge and the potential for rich multimedia interaction across great distances.

Many impressive initiatives are underway to harness the potential of this superhighway to develop and field resource intensive teletraining to distance learners. For example, the Total Army Distance Learning Program places priority on a worldwide system of dedicated classrooms with high end compressed digital video conferencing and resource intensive network requirements. While admittedly setting the stage for the future, many of these initiatives further isolate the organizations with learners that would most benefit from them. The more bandwidth required and the higher the cost, the fewer the sites and learners capable of participating.

DIGITAL DIRT ROADS

The transportation analogy of the Information Superhighway evokes images of knowledge travelling at high speeds from the world's great repositories to eager learners in organizations occupying choice real estate with quick access to on and off ramps. If we follow this analogy we see there are also many potential classrooms and learners in organizations on the periphery far from the high-speed system. They may be there because they can't afford the close-in real estate, their family ties are in the area or they prefer the lifestyle. For whatever reason, these customer organizations are down the digital equivalent of dirt roads. This challenge is also

inhibiting the growth of electronic commerce (Clinton, 1998).

Many target classrooms, learners and organizations, especially those in the Reserve Components of the Armed Forces, don't have direct access to the Information Superhighway. Instead, they live down the equivalent of digital dirt roads. These narrow paths provide slower access with limited throughput, usually less than 64 kilobits per second (kbps). In order to provide access to these organizations and learners and make distance learning cost effective, systems must be capable of delivering quality training down the digital dirt roads while providing scalability and flexibility to add features as the digital roads are widened and improved.

DISTANCE LEARNING

The Office of the Under Secretary of Defense for Personnel and Readiness (1999) defines distance learning as "structured learning that takes place without the physical presence of the instructor." The Department of Defense also stresses the importance of right-time, right place learning. The United States Army Training and Doctrine Command (1998) further defines distance learning as

> *"…delivering standardized training using multiple media and technologies when and where it is needed. It includes providing individual, collective, and self-development training to Army members and units. Distance learning may involve student-instructor interaction in both real time (synchronous) and non-real time (asynchronous). It may also involve self-paced asynchronous student instruction without benefit of access to an instructor."*

IMPERATIVE TO INCREASE ACCESS AND CONTROL COSTS

The major challenge of distance education is increasing access while controlling the cost of delivery. Meeting this challenge while maintaining effective instruction is crucial to achieving the return on investment necessary to insure the viability of distance learning programs. The imperative of access and cost effectiveness requires the selection of the least expensive alternative that meets the course objectives and reaches the intended audience. All things equal, the more access and less expensive the method, the better. Courseware designers and managers are expected to be good stewards of resources entrusted to them and expected to seek efficiency in their designs.

President Clinton (1999), in Executive Order 13111, *Using Technology to Improve Training Opportunities for Federal Government Employees*, recognized the imperative of increasing access while controlling costs by declaring the provision of the best education for employees at the lowest possible cost as an obligation of all Federal agencies. That same memorandum encouraged the use of new technologies to make education more accessible for all Americans.

TECHNOLOGY DETERMINES ACCESS AND COSTS

For distance learners, access to the technologies used by the providing institution for delivery determines access to education and training. Therefore, access to education and training is limited by the requirement for high bandwidth systems requiring dedicated, unique equipment and facilities. Organizations and students in rural areas and located at austere contingency operations sites are least likely to have access to broadband educational technology (Parrott, 1995).

The attention and efforts of distance education professionals are often diverted from stable, affordable, effective solutions by the allure of the latest, highest cost technologies (Sherry, 1996) (Russell, 1997).

The National Institute of Standards and Technology (1998) states

> *"Many educational technologies are high in cost, low in reliability, and difficult to adapt to special usability needs. Better use of information technology, including the Web and other networks, could reach more learners with educational material tailored precisely to their needs. The costs of producing and disseminating educational content would drop. The user community for instructional systems would expand and become more diverse."*

There is great potential to increase access to quality military training and education through the convergence of emerging network technologies and proven techniques. The demand to provide global access at affordable prices is especially important for the Reserve Components and other geographically separated organizations and learners.

ROLE OF SYNCHRONOUS DELIVERY

Distance education delivery systems are categorized as either synchronous or asynchronous. Synchronous delivery requires instructor and students to participate at the same time while asynchronous delivery allows participation at differing times. The main advantage of synchronous delivery is the provision for live interaction and the possibility of more natural group processes. The disadvantage is the requirement to adhere to a specific time frame that may not be convenient for all participants, especially those in other time zones (Steiner, 1995). Asynchronous delivery systems are characterized by the separation of the instructor and student in both place and time. Asynchronous systems allow anytime-anywhere learning, but are limited in student and instructor interaction.

As Chute pointed out, synchronous events are desirable in distributed learning programs in order to provide student to student interaction for peer learning and student to instructor interaction for mentored learning. Additionally, synchronous events provide a framework of calibration and expectations to keep students on track. Even programs that depend primarily on asynchronous learning benefit from periodic synchronous events. Synchronous learning activities leverage the great depth of expertise and qualities of the traditional classroom while expanding the physical reach to geographically separated learners (as cited in Christensen and Cowley-Durst, 1998).

SYNCHRONOUS METHODS

Many of the current synchronous delivery methods employed tend to use primarily text based computer mediated communications such as chat sessions or video based tele-training applications. Both of these have significant limitations.

Text

Text based communications require the participants to type their comments using a keyboard. These texts lack the rich, multimedia dimension of communications and can also lack spontaneity. The greatest advantages to this type of delivery are the low communications bandwidth required and the ability to save the text discussions for review later. However, very often the germane response to a probing question is composed, keyed and sent too late to flow with the discussion. Text messages are relatively shallow in respect to transferring the meaning of statements, especially those that are ambiguous or sarcastic. There are few provisions for word inflection or emphasis.

Video

Full motion video based communications require expensive, dedicated equipment and infrastructure as well as technical support personnel with specialized skills. The transmission of communications requires dedicated, high-speed lines and system operation requires extensive, specialized training. All of these considerations combine to dramatically increase the cost of operation and ownership. No single factor drives the costs of synchronous distributed learning more than the reliance on full motion video. Along with all these costs, video is also limited in quality of graphics due to the requirement to compress the video images. Limitations in interactivity are caused by the latency of the compressed audio and video signal, which results in participants talking over each other. The primary advantage of video is the social aspects of seeing the movement of participants. Although internet protocol based video systems show promise to reduce costs, the current state of the technology and lack of quality of service connectivity severely limits their effective use.

Audio

Although audio conferencing using the telephone is simple, inexpensive and extremely accessible, it is used very little for military training. The most significant drawback of audio conferencing is the lack of a shared graphical workspace that can be manipulated in instructionally significant ways by the instructor and students (Wisher, 1998). The switched telephone network is the most cost-effective system available for transmitting voice communications because of guaranteed quality of service, impact of open competition and governmental policies of universal service.

Audiographics

Audiographics is defined by Willis (1993) as

> *"…a sophisticated computer application relying on graphic computer interaction augmented by two-way, real time audio communication. Audio, data and graphics are shared over telephone lines, allowing users in different locations to simultaneously work on the same application."*

Audiographics is an effective and low-cost solution for synchronous interactive distance education in groups. This is the distance education model most like the current classroom approach, therefore course adaptation costs are reduced and the guiding role of the instructor is preserved (Sherry, 1996).

Audiographics has been recognized in the literature as one of the least costly interactive methods of delivering synchronous distance education (Bradshaw & Desser, 1990). In the late 1980s, its use escalated rapidly because of its cost effectiveness and ease of implementation (Gilcher & Johnstone, 1988).

Thousands of sites throughout the world are using audiographics every day to reach distant learners. Audiographics provides a cost-effective method of reaching widely separated sites with limited available telecommunication infrastructure. It is especially effective for quickly increasing access with modest expenditure of capital.

In the United States Federal Government, the Postal Audiographic Training Network (PATN) expanded to over 800 sites in 1996. The PATN provides maintenance instruction to every maintenance capable post office in the country from the national training center in Oklahoma (U.S. Postal Service, 1997).

As a critical part of its reengineering plans, the National Weather Service recently equipped each of its field offices with audiographics systems to participate in training originating from their national training center in Kansas City, Kansas. Topics include Radar Principles, Velocity Interpretation, Operational Applications and Weather Scenarios (National Weather Service, 1998).

THE HYBRID APPROACH

The future of communications and distance education is in networks and connectivity. However, the current Internet bandwidth and access speeds are inadequate for the delivery of true multimedia instruction combining sound, video, graphics and data (Kerka, 1996).

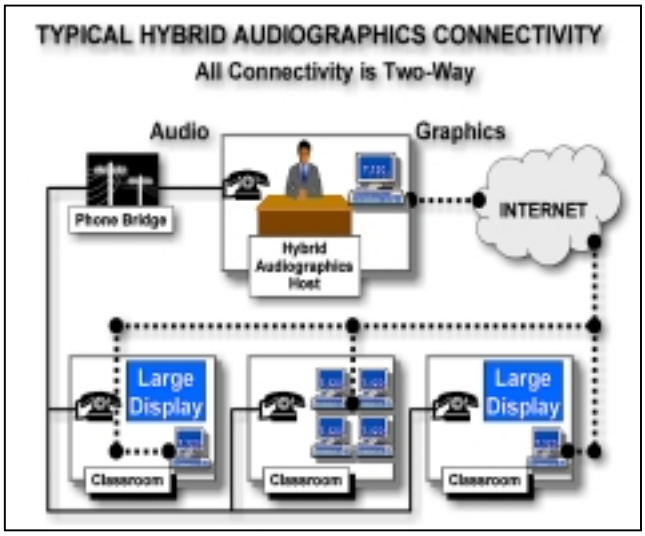
Hybrid approaches to distance education use a combination of technologies to increase capacity and choice in designing and delivering instruction. (Kidwell, 1998). Hybrid audiographics uses the public switched telephone network for voice transmission and the packet switched Internet for graphical data transmission. This combination distributes the transmission load between two highly accessible but limited bandwidth media, thus improving performance and eliminating the requirement for broadband connections to support real-time interaction.

HYBRID AUDIOGRAPHICS

The proliferation of low cost personal computers capable of rendering high quality graphics, adoption of international standards for multimedia conferencing, ubiquity of Internet access and universal telephone service have created the opportunity to deliver scaleable, low cost multimedia instruction with the hybrid audiographics approach. This consists of delivering high quality audio over telephone lines and data interaction over packet switched Internet connections. Costs are very low and it is accessible to any site with telephone service, a Pentium class personal computer and Internet connection. With the national information infrastructure initiatives, Internet access is available in essentially every community in the country and the switched telephone network is universally accessible.

Hybrid audiographics is much the same in results as older telephone based audiographic applications. Both use the standard switched telephone system for audio. However, audiographics originally required a dedicated phone line for graphics. Hybrid audiographics uses packet switched communications such as Local Area Networks (LAN) or the Internet for transmission of visual information and application controls. Multi-point conferencing can be accomplished for hybrid audiographic teleconferencing without the hardware requirements of older versions of audiographics (see Figure 1).

Figure 1. Typical Hybrid Audiographics Connectivity



With hybrid audiographics, teachers and learners can communicate by voice while interactively sharing and annotating visual information. Graphics can be simply and quickly prepared, even during delivery. Multiple locations can be reached at the same time. Instruction can originate from any of the participating locations therefore empowering decentralized distance education programs. Rural areas and less affluent schools especially benefit from a cost effective, lower bandwidth solution (Gooley, nd).

INTERNATIONAL STANDARDS

Hybrid audiographics uses the International Telecommunications Union (ITU) data conferencing standard known as T.120, which is a component of the family of multimedia conferencing standards known as H.32X. These standards insure worldwide interoperability. The H.32X standards promise to provide rich multimedia conferencing interoperability with integrated audio-video and data communication. However, the only component with guaranteed reliable transmission over the Internet is the T.120 data conference. Therefore, data conferencing is the most dependable method of shared visual digital interaction currently available over the Internet (The International Multimedia Teleconferencing Consortium, Inc, 1997).

Using the telephone provides quality of service for the audio channel by creating a virtual direct circuit in which all information is carried along the same route for the duration of the call. This insures high fidelity, real-time voice interaction at a relatively low cost. This approach to providing the voice channel results in more effective and interactive teleconferences since the quality of audio is the highest determinant of participant satisfaction (Tang & Isaacs, 1992). Analog telephone service is also essentially universal in the United States due to governmental policy and subsidies.

Using the packet switched Internet for data transmission allows graphics and application controls to travel in digital format along toll-free routes worldwide. The variable latency of the Internet is offset by error-free, guaranteed, full resolution transmissions (IMTC, 1997). While latency in audio would severely hamper natural communication, latency in graphics transmission is a relatively minor issue.

EFFECTIVENESS

Any study of distance education is incomplete without addressing effectiveness. The majority of research on the effectiveness of distance education over the last 50 years has shown there is no significant difference in learner performance due to technology or media. The most important factors are well designed lessons and courseware, not the technology used for delivery (Russell 1998). This is because the core knowledge content of the course should remain unchanged by the decision to deliver at a distance, although new strategies for presentation and additional preparation time for instructors may be required (Willis, 1992).

Video and audiographics have also been recognized to be the most preferred technologies for synchronous learning in groups (Duning et al, 1993). This is due to the shared nature of the visual workspace and the ability to focus and involve geographically separated groups.

Candidate courses and subjects for delivery via hybrid audiographics should meet the same requirements as audio only teletraining. They should be highly structured, knowledge based (vice hands-on) and have periodic written tests (Wisher, et al 1998). This accurately describes most instruction in higher education. The most significant limitation of audio teleconferencing found by Wisher was 'lack of a visual medium that an instructor can display, mark, manipulate and control instructionally in useful ways.' This lack of a visual medium is effectively addressed by audiographics with the added improvement of allowing learners to manipulate the shared information as necessary.

In a series of studies on teleconferencing effectiveness for group problem solving, audiographics was at least as effective as video conferencing. There was no significant difference between the quality or timeliness of decisions between study groups using video with audio compared with groups using graphics and audio (Tang & Isaacs, 1992).

In a study comparing the performance of groups of college students taking a graduate level statistics course via interactive satellite video, hybrid audiographics and traditional face to face lecture, there was no significant difference in cumulative course grades. Additionally, the costs associated with delivering hybrid audiographics were approximately one tenth as large as costs associated with delivering interactive satellite video (Freeman, 1999).

THE STUDY

In order to determine the potential effectiveness of hybrid audiographics for delivering distance learning, the U.S. Army Research Institute conducted a training experiment in conjunction with U.S. Army Reserve Readiness Training Center (ARRTC), Ft. McCoy, Wisconsin. This study was planned and

coordinated by the Office of Strategic Initiatives, Office of the Chief of Army Reserve with technical assistance from the Training Division, Deputy Chief of Staff for Operations, U.S. Army Forces Command.

The experiment used hybrid audiographics to train a four-day course on Information Operations and involved soldiers' ability to learn the material *with or without* a live video image of the instructor being provided during training. The experiment offered an opportunity to (1) assess a soldier's perceptions of seeing or not seeing the instructor, and (2) test any differences in learning. An overall assessment of the effectiveness of audiographics was also conducted. Soldiers from both Reserve and National Guard units participated in the course. The results were also compared to the traditional face to face delivery in a classroom.

Study Approach

Course

The course consisted of 11 instructional modules on an introduction to Information Operations, which concerns definitions, the nature of the threat, organizations involved and national Information Operations strategies. The training originated from the ARRTC and was transmitted to seven remote sites. The course was conducted over two weekends in February 1999. Three instructors from Booz-Allen & Hamiliton, Inc., under contract to the Land Information Warfare Activity, delivered the training. The instructors had experience teaching the same course in a residence mode. A written exam was administered at the end of the course, with a score of 70% or greater required for passing.

Equipment

Each of the seven remote sites was equipped with:

(1) an audioconferencing device for clear, two-way audio transmitted over an audiobridge connection.

(2) a personal computer and image projector to display slides transmitted over the Internet.

(3) a television monitor providing a live image of the instructor transmitted by compressed video over a commercial telephone line.

The instructors at Fort McCoy were able to view live images of the seven classes through seven television monitors. The slides were forwarded to the remote sites using the T.120 component of Microsoft NetMeeting™ software, through a central server running DataBeam™ T.120 software located at Fort McPherson, Georgia.

Experiment

Four of the 11 instructional modules, occurring in the middle of the course, were selected for the following manipulation:

(1) for two of the modules, the image of the instructor on the television monitor was turned off at three remote sites (but remained on at the other four sites);

(2) this procedure was reversed for two other modules. The interest was in testing the effect that seeing the instructor had on an individual's learning.

Note: At all times, the soldiers were able to view the slides and hear the instructor.

Evaluation

A pre-course survey was given immediately before the training began. This survey gathered demographic information on the participants as well as ratings as to the extent of prior knowledge on the 11 topics of training. At the end of the first weekend of training, an assessment of the effect of not having the television image of the instructor turned off was conducted as well as an assessment of how much more was learned on the topics covered. At the end of the training, the scored written tests were collected and a final assessment of both learning and the technical qualities of the course were taken.

Demographics

Soldiers from seven sites participated, with a total sample of 107 participants. The following sites participated:

US Army Reserve Sites:	# of Participants
Texas	27
Massachusetts	22
Virginia	7
US Army National Guard Sites:	
Vermont	15
Washington	15
Iowa	14
Oklahoma	7

Age: Average age was 37 years

Rank: Enlisted 46%; Warrant Officers 9%; Commissioned Officers 45%

Computer use per day: More than six hours - 53%; Four to Six hours - 25%; One to three hours - 19%; less than one hour - 3%

Figure 2. Map of Participating Sites

Performance

Performance Compared to Traditional Classroom

Overall, the training effectiveness of audiographics training was comparable to the traditional classroom. An analysis of variance using an independent samples t-test showed no significant difference on the written exam (the measure of learning outcome) between groups (t=.604, p=.55), with scores of 88.2% for the audiographics group (n=107, SD=6.7) versus 87.5 % for the traditional classroom group (n=108, SD=10.5). These results suggest there is no difference in performance between the audiographics mode of instruction and the traditional classroom for the Information Operations course.

Performance Compared to Motion Video

For the experiment with the TV image of the instructor on or off, the results of the students' perception of their learning were compared to their actual learning as measured by the written tests. An analysis of the subset of items on the written test relating to the four topics subject to the experiment was conducted. There were no significant differences in actual test performance (t=-.38, p=.71) for tasks that were viewed with the TV on (87.2%, SD=11.9) or off (86.6%, SD=11.9). The average self-assessed learning score was not significantly different for the TV on or off condition (t=.00, p=1.0). For both conditions learning was rated an average of 3.6 (SD=.97 on, SD=.89 off) on a five-point scale.

Overall Performance

Self-assessed and actual learning performance indicate that seeing the instructor produces no difference in Information Operations course performance.

TRANSMISSION COSTS

Transmission related charges comprise a substantial portion of the recurring costs for distance learning delivery systems. The typical transmission costs associated with the course were calculated and compared to transmission costs of full motion compressed video. For this purpose, the total connection time was 30 hours over two weekends. This included 26 hours of instruction and four hours for administration and call establishment. Costs were based on Federal Telephone Service rates of approximately 6 cents per minute ($3.60 per hour) for plain telephone and 10 cents per minute per channel for ISDN connections. Compressed video bandwidth required was assumed to be 384 kbps, the Army training standard, which requires six ISDN channels. Video multi-point conference unit costs were based on the Defense Information Systems Agency rate of 90 cents per minute per location. Total costs for video was calculated at $1.50 per minute or $90.00 per hour per site.

No costs were associated with use of the phone conference bridge since it was already installed and accessible. Most Army installations in the United States have phone conference bridges already installed which are under utilized during the typical periods for Reserve Component training, nights and weekends. Internet connectivity of at least 56 kbps was available in each classroom. No charge was associated with the U.S. Army Forces Command 100 port T.120 server for weekend and night use (see Table 1).

Table 1. Transmission costs

	# Sites	Costs per hour	Hours	Total
Video	8	$90	30	$21,600
Hybrid Audio-graphics	8	$3.60	30	$864

Hybrid audiographics transmission costs were calculated at approximately 4% of ISDN compressed video costs. It should be noted that both distance learning methods represent substantial savings over the travel and per diem costs of approximately $640 per student ($64,480) for residential instruction.

SUMMARY

Distance learning has the potential to enhance individual competency and unit readiness by delivering learning where needed and when needed. However, this requires the distance learning systems to be highly accessible. Since the technology selected for delivery in large part determines accessibility and costs, great care must go into selecting the most accessible, least expensive method that will meet learning objectives. There is a great challenge to provide increased distance learning access for organizations and learners that do not have dedicated on-ramps to the Information Superhighway. Hybrid audiographics is a viable method of reaching far down the digital dirt roads to dramatically increase access to learners and organizations while maintaining training effectiveness.

DISCLAIMER: The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense or the U.S. Government.

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