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Empirical Comparison of Alternative Video Teletraining Technologies

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The overall objective of the project was to explore technologically cost-effective ways to train personnel who are geographically remote from training resources. An empirical study was conducted to compare (1) training effectiveness and (2) user acceptance of live instruction and six different alternative Video Teletraining (VTT) technologies: multi-channel 2-way video with 2-way audio, single-channel 2-way video with 2-way audio, 1-way video with 2-way audio, 1-way video with 1-way audio, 1-way video with intermittent 2-way audio, and audiographics. Findings were that VTT in several different forms was effective both in terms of student performance and student and instructor acceptance. The most successful VTT technologies were those allowing continuous 2-way audio communication between classrooms with either 2-way or 1-way video. Using 2-way video does not appear to improve student performance as compared to 1-way video, but instructors prefer 2-way video and students expressed the desire to see their cohorts in other classes, which requires 2-way video. Student test performance was poorer with VTT systems that restricted remote students' ability to converse with or see the instructor and the performance decrement was evident in both local and remote classrooms. Evidence suggests that student acceptance of such VTT technologies was lower than with fully-interactive VTT. Similar results would be expected with video-taped instruction. Students adapted to compensate for the video and audio shortcomings of VTT technologies. The most serious shortcoming of the simulated VTT technologies was audio. Additional work needs to be done to refine the audio systems and procedures used in VTT.

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FOREWORD

This technical report describes work conducted as part of the Navy Personnel Research and Development Center's Communication Networks in Training (CNIT) project in the general area of remote-site training. The CNIT project is one part of the Schoolhouse Training product line and falls under the Personnel and Training Technology (NP2A) Block of the 6.2 Mission Support Technology Program Element 0602233, Work Unit RM33T23.02. The work was performed under the sponsorship of the Office of Naval Technology. The objective of the project is to find more cost-effective ways to train personnel who are geographically remote from training resources. The project has been exploring the use of new communication technologies to export training to geographically-remote students. Among these technologies are computer networking, instructional TV, videotape, audiographics, videographics, and other media. This technical report describes the results of a 6-month laboratory study involving 743 Navy students, which investigated the relative training effectiveness and user acceptance of live instruction, 2-way video, 1-way video, and audiographics. The findings have direct implications for the design of future distance education systems in the Navy and elsewhere.

The recommendations in this technical report are intended for use by the Chief of Naval Education and Training and Chief of Naval Operations (OP-11) in developing policy for the application of advanced communication technology in the Navy.

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SUMMARY

Problem and Background

Because of the wide geographic dispersal of home ports, fleet units, and Navy Reserve detachments, it is expensive to transport Navy personnel to a few facilities for classroom training. The costs involve transportation, travel expenses, and the travel time lost from duty. New communication technologies have the potential to reduce the cost of training. For example, Videoteletraining (VTT) can be used to deliver instruction with instructional TV and may link students and instructor across great distances. There are alternative VTT technologies that vary greatly in cost. The solution to the Navy's remote-site training problem lies in the proper selection and use of the most cost-effective communication technologies such as VTT.

Objectives

The overall objective of the project is to explore technologically cost-effective ways to train personnel who are geographically remote from training resources. The objective of the work described in this report was to conduct an empirical study comparing (1) training effectiveness and (2) user acceptance of live instruction and six different alternative VTT technologies: multi-channel 2-way video with 2-way audio, single channel 2-way video with 2-way audio, 1-way video with 2-way audio, 1-way video with 1-way audio, 1-way video with intermittent 2-way audio, and audiographics.

Method

The method included steps to (1) define assumptions and simulation requirements, (2) develop a research plan, (3) prepare for VTT training, (4) design and install a VTT laboratory, and (5) collect and analyze data.

Results

VTT, in several different forms, was effective both in terms of student performance and student and instructor acceptance. The type of VTT technology did influence student performance and attitudes, but had a far smaller effect than student experience.

The most successful VTT technologies were those allowing continuous 2-way audio communication between classrooms with either 2-way or 1-way video. Using 2-way video does not appear to improve student performance as compared to 1-way video, but instructors prefer 2-way video and students expressed the desire to see their cohorts in other classes, which requires 2-way video.

Student test performance was poorer with VTT systems that restricted remote students' ability to converse with or see the instructor and the performance decrement was evident in both local and remote classrooms. Evidence suggests that student acceptance of such VTT technologies was lower than with fully-interactive VTT. Similar results would be expected with videotaped instruction. Students adapted to compensate for the video and audio shortcomings of VTT technologies.

The most serious shortcoming of the simulated VTT technologies was audio. Additional work needs to be done to refine the audio systems and procedures used in VTT.

Recommendations

1. The Chief of Naval Education and Training (CNET) and the Naval Education and Training Program Management Support Activity should continue efforts to refine the CNET VTT network.

2. The Chief of Naval Education and Training and the Naval Education and Training Program Management Support Activity should analyze the feasibility and cost-effectiveness of extending the architecture of the CNET VTT network using VTT technologies such as 1-way video with 2-way audio and 1-way video with 1-way audio.

3. The Chief of Naval Education and Training and the Naval Education and Training Program Management and Support Activity should originate Problem Description and Need Justifications to continue the investigation of the applicability of VTT beyond lecture-based courses (e.g., in courses using "hands-on" laboratories, small-group, and other training processes).

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INTRODUCTION

Problem and Background

A requirement exists to train Navy personnel who are geographically remote from training resources. This requirement exists throughout the Navy, but is perhaps most obvious for personnel aboard ships at sea. Shipboard training is limited by available training resources and the skills of shipboard trainers. By necessity, personnel are periodically assigned to formal schools to receive training they cannot receive aboard ship. The locations of existing training facilities often require fleet personnel to travel away from their home duty station to complete required training. The remote-site training requirement also exists in the Navy reserves. Reservists typically belong to small detachments, widely dispersed geographically, with limited training resources, few qualified trainers, and little time to train. The requirement to overcome geographic distance in training delivery is a generic problem that exists in civilian public education and industry as well as the military.

Evolving communication technologies have the potential to reduce the impact of geography on training. Compressed-bandwidth TV, for example, can link instructors and students across distance and permit travel to occur electronically rather than physically. Several other technologies can also bridge distance. These include videotape, audiographics systems, electronic mail, audio conferencing, computer-aided instruction, and paper media. A solution to the Navy's remote-site training problem lies in the proper selection and use of new communication technologies. In general, these technologies are costly and constantly changing. Many forms of communication technologies are being used on a regular basis, and in demonstration projects. Investigators are exploring strengths and limitations, cost-effectiveness, and other dimensions governing suitability for different applications. Unfortunately, there is no road map or checklist to follow to determine which technology is "best" in a particular application today and which will be "best" next week, next year, or 10 years from now. The Communication Networks in Training (CNIT) project is exploring different technologies, research and development projects, and the Navy's training problems to gain a better understanding of which technologies hold the greatest potential for future use in the Navy.

Objectives

The primary objective of the CNIT project is to find more cost-effective ways to train personnel who are geographically remote from training resources. This objective is being addressed along four different tracks:

1. Assess the applicability of new communication technologies to the solution of Navy training problems.

2. Design, develop, and evaluate an experimental, computer-based instructional support network.

3. Design, develop, and evaluate an experimental, 2-way videoteletraining (VTT) system.[1]

[1]The term "videoteletraining" derives from "videoteleconferencing," a technology initially used for conducting TV conferences. The technology uses digital video compression techniques to allow communication via 2-way TV within narrower bandwidths than are used in traditional instructional TV. VTT is an evolutionary form of instructional TV.

4. Investigate the impact of alternative equipment configurations and training protocols on training effectiveness in a VTT laboratory

Work on tracks 1, 2, and 3 was completed during FY89 and is reported in Simpson (1990), Simpson & Pugh (1990), and Simpson, Pugh, & Parchman (1990). A field survey of VTT systems in public education, industry, and the military was conducted as a prelude to experimental work on track 4 and is reported in Pugh, Parchman, & Simpson (1991). The present technical report describes experimental work performed on track 4 during FY91.

Research Issues

Several different technologies can be used to deliver instruction to students at a distance. The technologies vary in capability and cost. They may also vary in instructional effectiveness and acceptance by instructors and students. The impact of technology on learning and attitude factors is not adequately understood.

Distance Education Technologies

Distance education technologies enable instruction to occur over geographic distance, with the instructor at one location and students at another. Several such technologies are available. Those most suitable for Navy training enable groups of students to be trained simultaneously in an organized classroom situation much like a live classroom and, ideally, allow instructor and students to participate synchronously (i.e., instructor teaches and students learn at the same time). Based on this dual standard, such technologies as electronic mail, computer-aided instruction, and paper media may be excluded. The remaining candidates are various forms of instructional TV, audiographics, and videotape.[2] These technologies vary in terms of their surface features, potential for instructor-student interaction, complexity, and cost. All have been used to deliver instruction effectively in public education, though most have been used only to a limited degree in Navy training. Research has shown that 2-way TV is an effective method to deliver Navy training (Rupinski & Stoloff, 1990; Simpson, Pugh, & Parchman, 1990). The Chief of Naval Education and Training's VTT Implementation and Management plan (CNET, 1990, June) envisions the eventual installation of a nationwide, multipoint, satellite-based VTT network for delivering training to Navy personnel. This system would be modeled on CNET's prototype Electronic Schoolhouse Network (CESN), which is headquartered at Norfolk, VA, at Fleet Combat Training Center, Atlantic, and with nodes at Norfolk and Dam Neck, VA, Charleston, SC, and Mayport and Pensacola, FL. The network uses 2-way video; that is, all sites on the network can both broadcast and receive TV. CNET's future training network, modeled on the prototype, would be primarily a 2-way system, although it would also include some receive-only sites; that is, sites that would not be able to transmit TV.

Instructional TV has been used in public education for decades. Currently, there are hundreds of such systems, ranging from the simplest single-campus closed-circuit TV systems to nationwide networks linking dozens of campuses (U.S. Congress, 1989). Most of these systems use 1-way video; that is, students at remote sites can see the instructor at the originating or "local" site, but the

[2] Videotape does not permit synchronous participation in training of instructor and students, but is similar to instructional TV in most other respects and so is included as a candidate.

instructor cannot see the students (Pugh, Parchman, & Simpson, 1991). This is especially true when there are many students at multiple remote sites. Return audio links from remote sites to the instructor may be provided (usually via telephone) to permit students to ask questions and interact with the instructor. The Army's Satellite Education Network, based at Ft. Lee, VA, is built on this model, and has been successfully used for several years to deliver courses in contracting, logistics, and other topics (Brockwell, 1989).

In some cases, instructional TV systems are entirely 1-way and students can only watch and listen, without being seen or heard by the instructor. Videotapes are being used increasingly to support live instruction, although there have been few attempts to use videotape to supplant live instruction altogether. Audiographics systems are a relatively low-cost alternative to instructional TV. These systems typically link sites via telephone lines and permit each site to transmit and receive audio and still-frame graphics that can be annotated (Pugh, Parchman, & Simpson, 1991). Table 1 summarizes the attributes of several alternative distance education technologies. Each of these technologies is discussed in greater detail below.

Table 1

Attributes of Alternative Distance Education Technologies

System Type	Students See & Hear Instructor	Students See Graphics	Instructor Sees Students	Instructor Hears Students	Synchronous Participation
2V/2A	+	+	+	+	+
Multi-channel 2V/2A+	+ (continuous)	+ (continuous)	+ (continuous)	+	+
1V/2A	+	+	-	+	+
1V/1A	+	+	-	-	+
Videotape	+	+	-	-	-
Audiographics	-	+ (continuous)	-	+	+

Two-Way Video with 2-Way Audio (2V/2A). 2V/2A is primarily a conferencing medium, but is being used increasingly in education. The architecture of 2V/2A systems is illustrated in schematic form in Figure 1. As shown in Table 1, 2V/2A systems permit students to see and hear instructor and instructor to see and hear students. Sites have multiple cameras and can switch among them. Thus, the local site can switch its output between an instructor camera and a graphics camera, but can only send one channel at a time. The remote (receiving) sites can switch output between a student camera and a graphics camera, but can only send one channel at a time. There are generally one local site and one or more remote sites. Sites may have additional cameras and be able to switch to send them out as well. Audio is continuous and any person speaking at either site may be heard by people at other sites, although there are generally rules governing when to speak and student microphones may be muted at certain times. Instructor and students participate in training synchronously. 2V/2A has been used successfully for Navy training in the CESN, the west coast VTT demonstration project, and in public education.

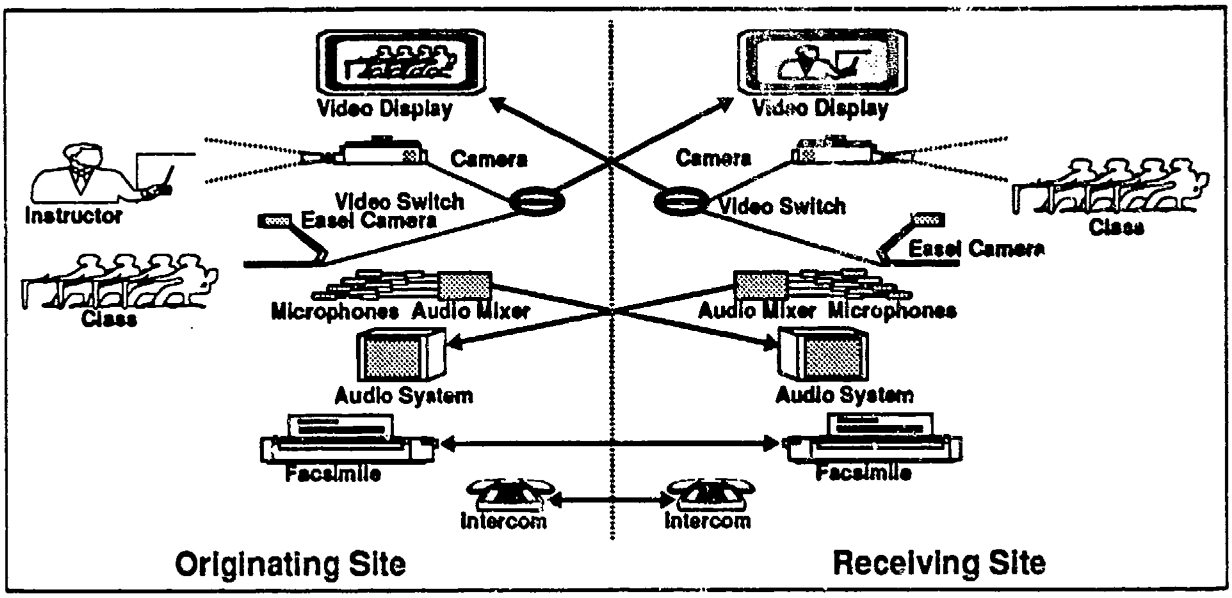

Figure 1. Hypothetical architecture of 2V/2A VTT system.

Multi-Channel 2-Way Video with 2-Way Audio (2V/2A+). 2V/2A+ is a logical extension of 2V/2A in which each video source is transmitted on a separate channel instead of switched on a single channel. Thus, for example, a remote class would observe the instructor on one video display, graphics on a second, and the local class on a third. Such an arrangement permits the remote class environment to more closely approximate that of the local class. The architecture of such a system is illustrated in schematic form in Figure 2. As shown in Table 1, the attributes of a 2V/2A system differ from those of a 2V/2A+ system only in that video is in the first case switched and in the second continuous. We are not aware of any existing 2V/2A+ VTT systems.

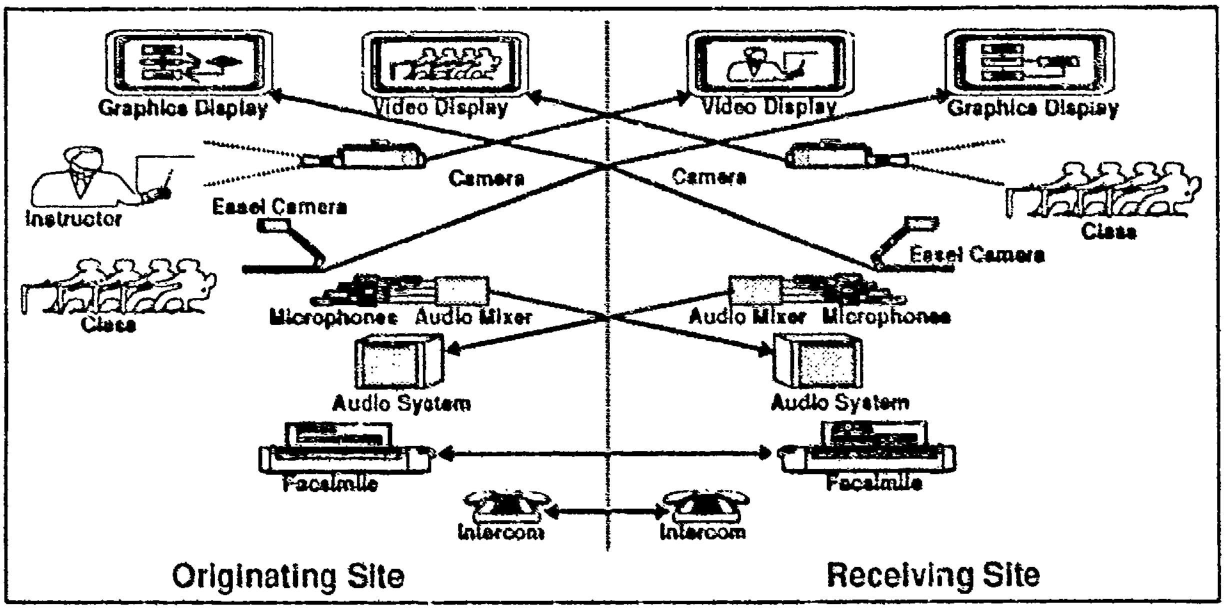

Figure 2. Hypothetical architecture of 2V/2A+ VTT system.

One-Way Video with 2-Way Audio (1V/2A). 1V/2A is widely used in education.The architecture of 1V/2A systems is illustrated in schematic form in Figure 3. As shown in Table 1, 1V/2A systems permit students to see and hear the instructor and the instructor can hear but cannot see students. The local site has multiple cameras and can switch among them. Receiving sites do not transmit video. As with 2V/2A systems, there are generally one local site and one or more remote sites, audio is continuous, and instructor and students participate in training synchronously.

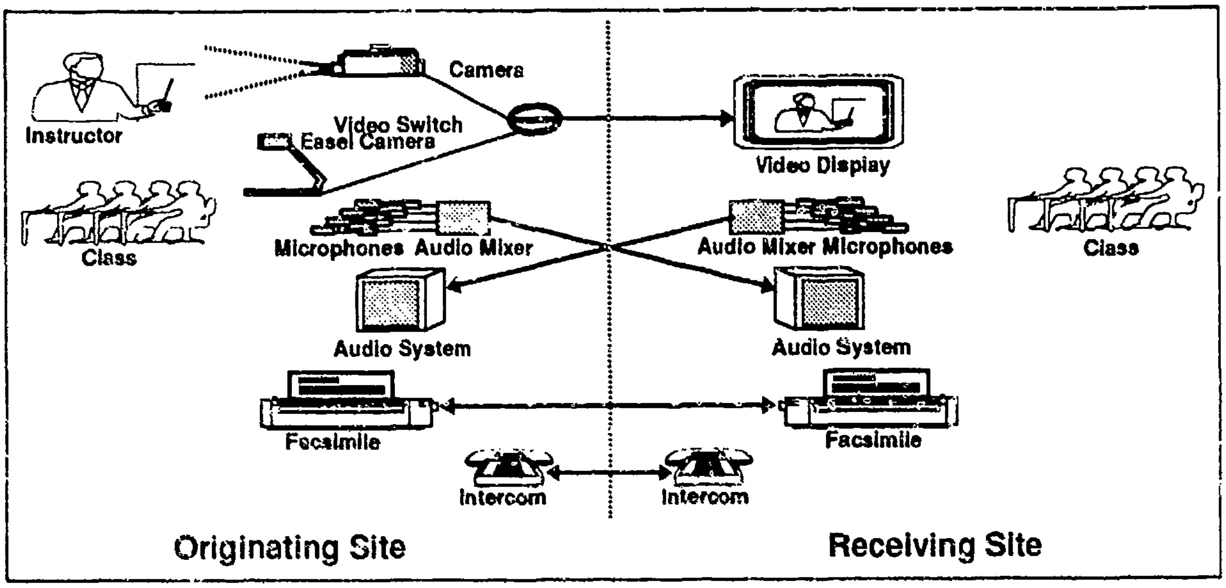

Figure 3. Hypothetical architecture of 1V/2A VTT system.

One-Way Video with 1-Way Audio (1V/1A). 1V/1A is widely used in education. The architecture of 1V/1A systems is illustrated in schematic form in Figure 4. As shown in Table 1, 1V/1A systems permit students to see and hear the instructor but the instructor cannot see or hear students. The local site has multiple cameras and can switch among them. Receiving sites do not transmit video or audio. As with 2V/2A and 1V/2A systems, there are generally one local site and one or more remote sites, audio is continuous, and instructor and students participate in training synchronously.

One-Way Video with 1-Way Audio (1V/1A). 1V/1A is widely used in education. The architecture of 1V/1A systems is illustrated in schematic form in Figure 4. As shown in Table 1, 1V/1A systems permit students to see and hear the instructor but the instructor cannot see or hear students. The local site has multiple cameras and can switch among them. Receiving sites do not transmit video or audio. As with 2V/2A and 1V/2A systems, there are generally one local site and one or more remote sites, audio is continuous, and instructor and students participate in training synchronously.

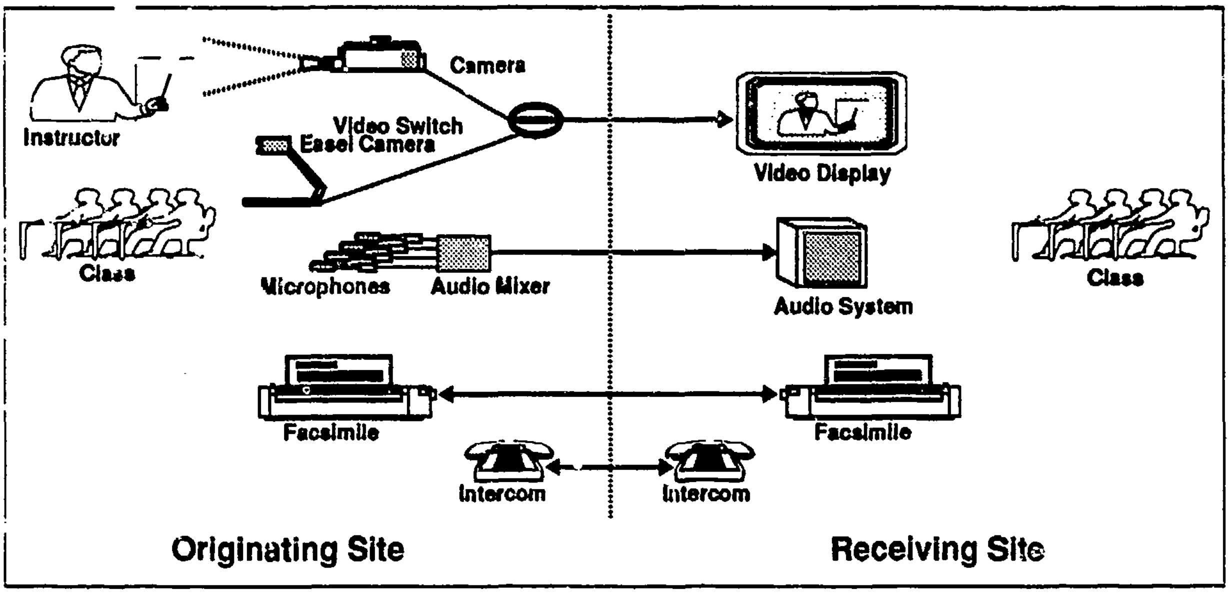

Figure 4. Hypothetical architecture of 1V/1A VTT system.

Videotape. The architecture of a videotape-based VTT system is illustrated in schematic form in Figure 5. The local site may be identical to a 1V/2A site (it may not include a local audience), but the remote site consists of a videocassette recorder and a video display. As shown in Table 1, videotape permits students to see and hear the instructor but the instructor cannot see or hear students. The local site has multiple cameras and can switch among them. Receiving sites do not transmit video or audio. As with 1V/2A systems, there are generally one local site and one or more remote sites and audio is continuous, but instructor and students do not participate in training synchronously. Note that the only difference between 1V/1A and videotape is synchronicity of participation. It is possible to enhance 1V/1A or videotape instruction by providing an intermittent audio link between students and instructor.

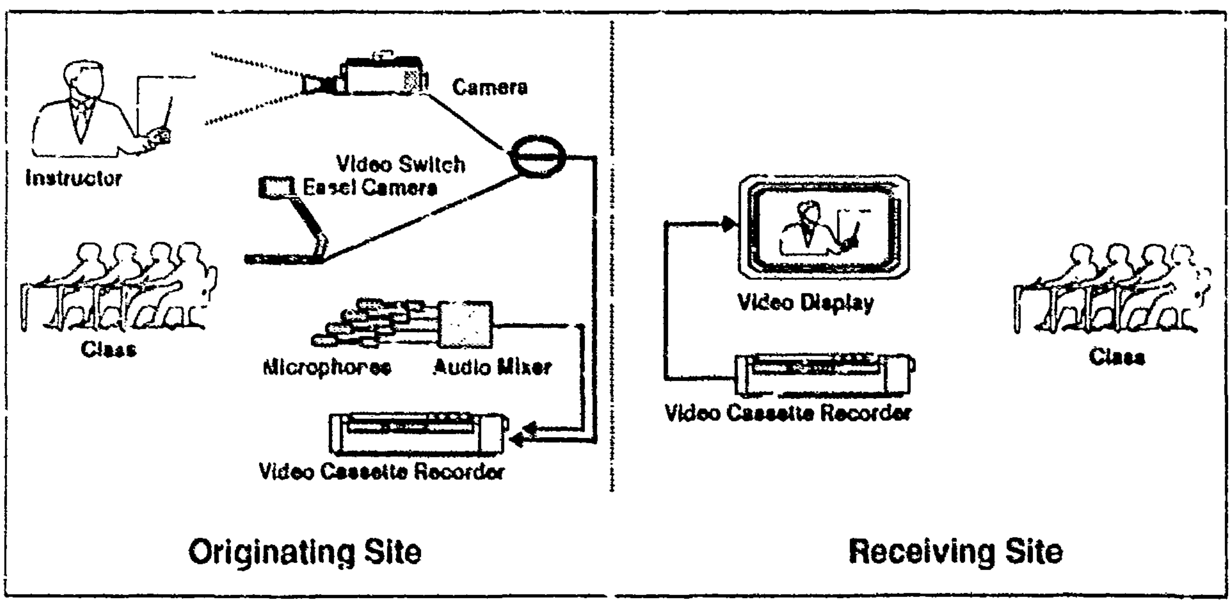

Figure 5. Hypothetical architecture of videotape-based VTT system.

Audiographics. Audiographics systems can be built using technologies that allow a local site to interact via 2-way audio with a remote site and to send images to a remote site using telephone lines. Two common technologies are slow-frame video and computer networks where a central computer communicates with remote computers to key the display of stored video images. The architecture of a hypothetical audiographics system is illustrated in schematic form in Figure 6. As shown in Table 1, audiographics systems do not allow students or instructor to see each other, but graphics are displayed continuously, the instructor can hear the students, and instructor and students participate in training synchronously.

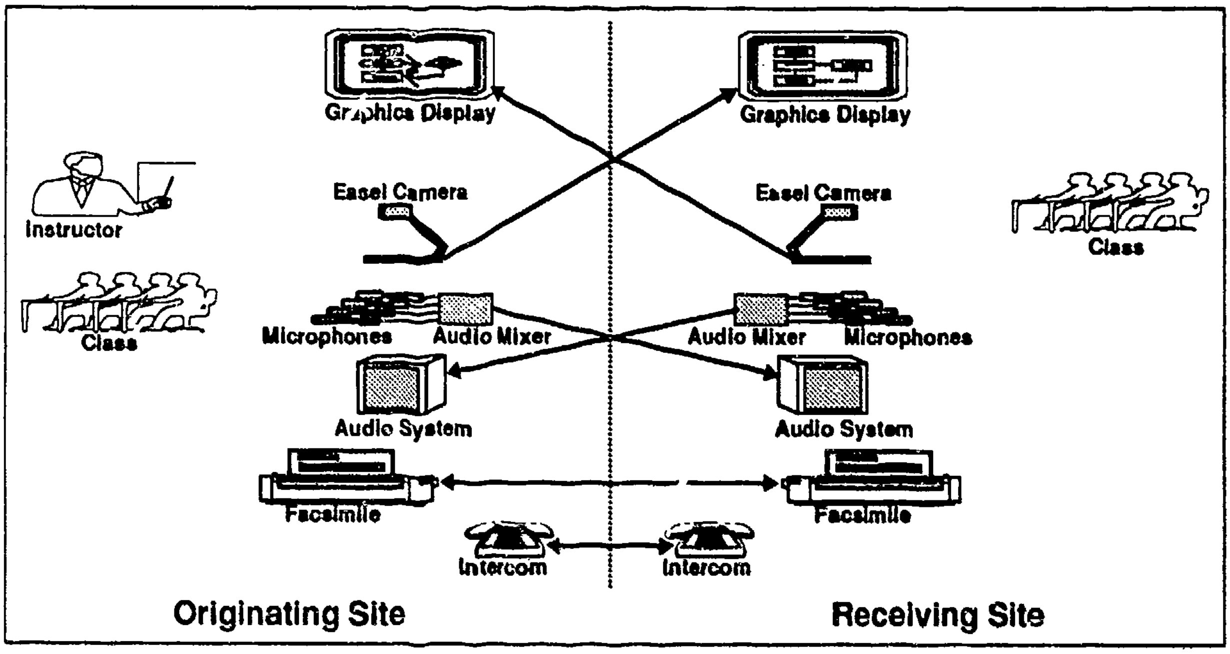

Figure 6. Hypothetical architecture of audiographics-based VTT system.

Cost Differences Among VTT Technologies

Cost differs greatly among the VTT technologies. Those who contemplate the installation of a VTT system should consider costs carefully before implementing it and realize that many systems fail for cost reasons. Hershfield (1986, July) surveyed several distance education systems that failed and concluded that a common error was the tendency to focus attention on the systems as ends in themselves before planning how they would be used. Ultimately, large amounts of money were wasted and system users became disillusioned. The author cited the Learn Alaska Network as an example of this confusion and the huge waste that can occur as a result. In Learn Alaska, $30,000,000 were invested in building a network that was shut down a few years later because of declining revenues and failure to meet its goals. Hershfield stressed the importance of conducting careful, realistic cost-benefit analyses before committing resources to system implementation, and cautioned that the dark side of embracing high technology solutions is high cost that may ultimately doom the system. Implicit in this argument is that risk is reduced as the cost of the VTT technology used is reduced, as long as low cost systems can satisfy the instructional/communications requirements.

It is difficult to obtain comparative cost figures for alternative VTT technologies. Published estimates are based on a host of assumptions and are usually dated. Cost changes as technology evolves, so estimates more than a year old may be inaccurate. Moreover, the cost of a particular VTT technology is governed by the specific details of its implementation (e.g., how many classrooms, their distance from one another, the type of communication links and VTT hardware used, hours of operation per year, etc.). Still, it is necessary to come to terms with the cost issue and even a crude analysis reveals that there are enormous cost differences among technologies. TV-based technologies (2V/2A+, 2V/2A, 1V/2A, 1V/1A) are more expensive than videotape or audiographics by orders of magnitude. Of the TV-based technologies, the capital cost of 2V/2A+ and 2V/2A are close but communication costs (e.g., satellite transponder lease costs) are greater for 2V/2A+ in proportion to the number of extra channels. 1V/2A is generally less costly than 2V/2A because receiving sites do not transmit video but only audio (which requires much less bandwidth), reducing communication cost greatly. 1V/1A is less costly than 1V/2A because receiving sites do not transmit any video or audio information back to the originating site, and, therefore, do not require equipment to transmit (e.g., audio system, phone lines, satellite uplink) or incur communication costs. In gross cost terms, the technologies tend to shred out into high cost (2V/2A+, 2V/2A), moderate cost (1V/2A, 1V/1A), and low cost (videotape, audiographics) alternatives, with roughly an order of magnitude cost difference between levels.

Differences Among Technologies and Instruction

The distance education technologies described differ in terms of the dimensions described earlier (see Table 1) and probably in other less obvious ways. These differences make it reasonable to predict that there will be differences in student performance and instructor and student attitudes depending upon the type of technology used to deliver training. For example, 2-way video systems (2V/2A and 2V/2A+) would appear to provide the greatest potential for instructor-student interaction, as instructors and students can both see and hear each other. One-way video systems with audio links (1V/2A) constrain interaction, as the instructor can hear but cannot see students. Still more constraining are 1-way video systems without a return audio link (1V/1A) or videotape instruction, as both eliminate the possibility of instructor-student interaction. Audiographics systems generally limit video displays to still frames, with real-time annotations, but permit full 2-way audio interaction.

Such a common sense analysis suggests that instructional effectiveness will increase with technological complexity and cost. Unfortunately, common sense is not the same as hard evidence and cost does not increase a little but by orders of magnitude as technology shifts from, say, audiographics to 1V/1A or 1V/2A to 2V/2A. For decision makers, the main question is whether the utility of a particular technology justifies its cost. To answer the question, one must determine (1) technology utility in terms of objective metrics such as student performance or user acceptance and (2) cost. Cost can be estimated by designing a hypothetical system and determining capital investment and operating costs. Determining technology utility is more difficult because the available hard evidence is sketchy and not always trustworthy. In any given year, the professional journals and trade magazines catering to distance educators and teleconferencers publish a great many articles on new, experimental, and existing distance education systems, and almost invariably the reports are of successes in meeting educational or other stated goals. Anecdotal reports and reports by contractors or other parties with a vested interest in system success are common. Reports of controlled research studies are rare. Also rare are reports of system failures or comparative studies of alternative distance education systems.

A comparative study of some of the alternative VTT systems discussed in this report was conducted by Beare (1989). Beare compared six alternative distance education delivery methods in a continuing education program. The methods used were live lecture, lecture with videotape backup, TV lecture with 2-way telephone hookup with microphones and a loudspeaker at all sites (equivalent to 1V/2A), audio-cassette assisted independent study, videotape-assisted independent study (similar to 1V/1A), and videotaped instruction with a question and answer session overseen by a graduate student (similar to 1V/1A with intermittent audio). Subsequent analyses of tests and student course evaluation forms revealed no statistically significant differences among groups, although comments indicated that students preferred live instruction to distance education alternatives. Beare concluded that the research demonstrated that a variety of inexpensive, affordable alternatives to face-to-face instruction were both effective and acceptable to students, but cautioned that distance education was not received favorably by students who had a clear option for face-to-face instruction.

The finding of no significant difference among technologies, as in Beare's research, is common in comparative studies and has led some observers to take the philosophical position that medium does not really matter. Clark and Sugrue (1990) recently conducted a meta-analysis of several different reviews of the research relating to the impact of medium on learning and concluded that no medium contributed unique learning benefits that could not be obtained from another medium. Along the same lines, Nadel (1988), noting that student attitudes did not seem to be influenced by the type of distance education technology, concluded that students learn from any medium, in school or out, whether they intend to or not, providing the content of the medium leads them to pay attention.

Though few studies have compared a family of related technologies, many have compared two or three. These, in aggregate, may enable one to extrapolate about the relative utility of different technologies.

2V/2A has been used successfully for Navy training in the CESN and in the west coast VTT demonstration project. In both cases, evaluations have shown student performance and attitudes to be comparable at local and remote sites (Rupinski & Stoloff, 1990; Simpson, Pugh, & Parchman, 1990). No direct comparisons to live instruction were made in either evaluation; the control condition was a local classroom in a VTT system. In both cases, the implicit assumption was that performance in the local classroom would be very similar to that in a live classroom and in both cases only small differences were found in performance and attitudes between local and remote classrooms. Denton, Clark, Rossing, and O'Conner (1984, April) collected student performance and classroom behavioral data during 2-way interactive TV presentations by professors in the College of Medicine at Texas A&M University. Thirty-two presentations, half televised and half live, by seven different faculty members were observed over 9 months. Results indicated that similar instructional strategies were used by the instructors regardless of presentation mode and that student achievement was comparable in live and TV classes.

Nadel (1988) compared student performance and attitudes in live and remote classes within the 1V/2A TV network at the University of Southern Maine and found no difference in achievement or attitudes between live and TV classes. Nadel did find individual differences among students: students had more positive attitudes toward TV-based instruction as a function of their age, enthusiasm, and preference for structure, and more negative attitudes as a function of their preference for collaboration.

Platten and Barker (1987, June) described an informal evaluation of a graduate course delivered via the TI-IN network, which uses 1-way video and 1-way audio but allows students to call in via telephone (equivalent to 1V/1A with intermittent audio). Many students were reluctant to call and there were delays and difficulties in coordinating calls from different sites. Instructors believed that lessons given via TV had to be better organized than those given live and found teaching without being able to see students challenging. Most students felt that instructional TV maintained their interest as well as live instruction but preferred live instruction.

Chute, a researcher on the staff of the National Training Center, a subsidiary of AT&T, has published extensively on the use of proprietary AT&T audiographics-based teletraining systems. Chute, Balthazar, and Poston (1988) summarized 5 years of research and development in the application of these systems in corporate and higher education. Studies comparing live training with teletraining using 2-way audio and an electronic conference board demonstrated that students learned better with teletraining and generally reported a high level of satisfaction with it, though satisfaction was governed by several factors, including job relevance, cost, video quality, degree of interactiveness, instructional appeal, student needs and expectations, and other factors. There continues to be some learner resistance to teletrained instruction. Knapczyk (1990, 1991) reported on the successful use of audiographics to support in-service programs for teachers and other professionals.

These studies provide insight into VTT technology utility but are clearly too limited to provide definitive answers. Moreover, most studies took place in the academic or business world, and it is reasonable to expect that the results might not apply equally to Navy personnel. The research described in this report is intended to provide additional data on technology utility to aid decision making concerning the selection of technologies for use in future Navy distance education systems. The research described is a comparative study of live instruction and six different simulated VTT technologies based on those sketched earlier in this report.

METHOD

Overview

The method included steps to define assumptions and simulation requirements, develop the research plan, prepare for VTT training, design and install the VTT laboratory, and collect and analyze data. These steps are described below.

Assumptions and Simulation Requirements

Assumptions

Our research into VTT technologies was based on several assumptions:

1. VTT technologies can be simulated in a laboratory consisting of two separate classrooms using closed-circuit TV. It would have been prohibitively expensive to conduct research with actual VTT systems. The laboratory simulations reduced cost, provided greater control, and increased observational opportunities.

2. VTT training delivery procedures can be adapted from those of traditional live instruction with minor modifications (e.g., refined visual aids, slightly more structured questioning and testing procedures).

3. High production values are not essential.

4. Students are present in both local and remote classrooms.

5. Simulations minimize personnel requirements. The cost of distance education systems increases with number of training, operating, and support personnel. Simulations use one instructor (local classroom), one facilitator who is not a subject-matter expert (remote classroom), and an on-call technical support person (local and remote classrooms).

6. Class size is approximately 20 students per classroom.

7. VTT simulation does not require compressed-bandwidth TV. Many of the technologies to be simulated would, if implemented, use compressed-bandwidth TV with codecs (coder-decoder) at transmitting and receiving ends. We considered using codecs in the laboratory but rejected the idea because codecs would add unnecessary complexity and expense. The research did not require codecs because the independent variable to be investigated (type of VTT technology) was orthogonal to the video dimensions a codec would affect (e.g., video quality, frame rate, and slight time delays).[3]

Simulation Requirements

The VTT laboratory had to simulate the VTT technologies listed in Table 1, allow easy, rapid changes among simulated technologies, and provide additional capabilities for possible future growth. The following requirements were specified:

Communication links: Video (four channels), audio (two channels), intercom/facsimile (three channels).

Classroom video: Up to four cameras (switchable) with large-screen TV displays for class and small-screen TV monitors for instructor and researchers.

Classroom audio: Audio mixer with sound-activated microphones for instructor and up to 30 students and matching public address system.

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[3]Other arguments against using compressed-bandwidth TV are (1) the level of video quality for a given bandwidth is constantly increasing as algorithms are improved, (2) there is no recognized way to quantify video quality, and (3) the quality of compressed-bandwidth TV is converging toward conventional analog TV. The use of closed-circuit rather than compressed-bandwidth TV has implications for interpretation of the results, as discussed in the Results section.

Intercom: One telephone handset.

Facsimile: One fasimile.

Instructor's workstation: Lectern, table, easel camera, and video switch.

Simulation requirements were identical in local and remote classrooms. All equipment identified above except communication links (which were shared) had to be duplicated in both classrooms.

Research Plan

The research plan is described below in terms of its research objective, research design, dependent variables, data collection methods and instruments, subjects, and data collection.

Research Objective

The research objective was to investigate the relative training effectiveness and acceptance by students and instructors of the type of VTT technology used. The baseline for comparison was traditional live instruction. It was not expected that any VTT technology would improve training effectiveness or acceptance; parity with live instruction would validate the technology.

Research Design

The research design is illustrated in Table 2. The independent variable was type of VTT technology. Seven different research conditions, each corresponding to a separate technology, were simulated in the laboratory. In condition 1 (live instruction), the instructor taught a single live class in the VTT laboratory. In conditions 2-7, the instructor taught a live class in the local classroom and a remote class via a simulated VTT technology.

Table 2

Research Design

Research Condition	Local Classroom	Remote Classroom
1	Live	N/A
2	Live	2V/2A+
3	Live	2V/2A
4	Live	1V/2A
5	Live	1V/1A
6	Live	1V/1A+
7	Live	Audiographics

Research conditions 2-7 correspond to VTT technologies listed in Table 1 with two exceptions. First, the research design does not include a condition corresponding to videotape. The attributes of videotape are essentially identical to 1V/1A (see Table 1); only the 1V/1A condition was included in the design. Second, the design includes an enhanced 1V/1A condition (condition 6, referred to as 1V/1A+), which allows intermittent 2-way audio communication in what is primarily a 1V/1A simulation; this communication occurred at six specific times during the instructional day for an elapsed time of approximately 15 minutes each.

Audiographics was simulated by combining 2-way audio with a 1-way TV broadcast of an easel camera display. Note that this simulation differs from audiographics technologies which display computer-based images.

Dependent Variables

Dependent variables were student performance on written examinations (daily quizzes and final) and student attitudes on several different factors as reflected in written course evaluations. In addition, data were collected concerning classroom processes, classroom observation log entries, and instructor debriefings. All forms of data were collected for all research conditions. The methods and instruments used to collect these data are described below.

Data Collection Methods and Instruments

Student background questionnaire: Students completed a one-page "Student Survey" (Appendix A) at the start of each course. The questionnaire provides information on student seniority and course subject-matter experience.

Final examinations: Written final examinations were administered to students at the end of the course. The exams were taken "open book" and consisted of 50 fill-in items. There were two equivalent forms of the final.

Daily quizzes: Written 15-item quizzes were administered to students at the beginning of class on days 2, 3, and 4. The exams were taken "open book."

Student course evaluations: Attitude measures were obtained using Likert rating scales on a series of questions relating to the instructor, audio-visual aids, tests/homework, overall assessment, and instructor-student interaction. The questionnaire included a series of semantic differential items relating to course content and form of instruction. Student comments on the class were gathered in a series of open-ended questions. A sample evaluation questionnaire is contained in Appendix B.

Observations: Navy Personnel Research and Development Center (NPRDC) observers were present in the receiving classroom on days 1, 2, and 3 of each week. The observer sat in the back of the classroom at a table containing two 13" TV monitors. One monitor showed the view from the front of the local classroom and the other the view from the front of the remote classroom. From this vantage point, the observer could see all students in both classes on TV and observe the remote class directly. The observer maintained a written log describing significant events in the class as they occurred (e.g., instructor-student interactions, training activities, problems, technical difficulties). In addition, twice during days 2 and 3 of each week the observer filled out a "Classroom Interaction Analysis Form" to record the classroom processes in a structured way. A sample form is contained in Appendix C.

Instructor debriefings: Instructors were debriefed by NPRDC researchers each week on the morning following the final day of the class. By this time instructors had graded tests, reviewed student questionnaires, and reflected on their classroom experiences during the week. Instructor comments were recorded in the classroom log.

Subjects

Subjects were Navy active duty and reservist personnel undergoing training required by their duty position. Students were assigned to a classroom (local or remote) by the 3M instructional staff, who attempted to balance the relative sizes and seniority of local and remote classes. Each classroom typically contained about 20 students. Average class sizes for local and remote classrooms as a function of research condition and classroom are given in Table D-1.[4]

Seniority (rank) was assumed to reflect 3M knowledge and experience and a seniority index was computed for each class by assigning a number to each student based on rank and computing the average for the class. The ranking scheme was E-1 through E-4 (1), E-5 (2), E-6 (3), E-7 through O-2/WO-1 through WO-4 (4), O-3 through O-5 (5). For example, a student with the rank of E-4 would be assigned the number 1, an O-2 would be assigned a 4, and so forth. The assumption and ranking scheme enable comparison of seniority level as a function of research condition and classroom (Table D-2). Seniority varied across research conditions and variance due to this factor was handled statistically during data analysis (see Results).

Data Collection

Data were collected over a 6-month period with two breaks. Our strategy was to collect data for a particular research condition during 3 successive weeks, reconfigure the laboratory as necessary to simulate the next condition, collect data for that condition for 3 weeks, and so forth. The order in which data for the different research conditions was collected was 1, 3, 4, 2, 6, 7, 5. The extended 3-week data collection periods enabled instructors to become familiar and comfortable with the particular technology simulation, provided a large subject pool for statistical analyses, and balanced out some of the extraneous factors beyond our control (see below).

The research was conducted within a Navy schoolhouse, which meant that our research could not impose training conditions on students that might irreversibly compromise their learning. To avoid possible problems in the more austere research conditions (5, 6, and 7), a decision was made to impose each research treatment during only the second day of the 4-day course rather than for the entire 4 days. We were thus able to assess student test performance on course content covered during day 2 with a quiz on the day following the research treatment, which would have enabled remediation if student learning had suffered. It would have been preferable to impose the research treatment for the entire course but this was not feasible within the schoolhouse environment.

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[4]Because of the large number of tables in this report, only tables of primary interest are presented in the body of the text. Tables of secondary interest are in Appendix D.

Six different instructors and three different facilitators participated in the research. Personnel assignments were governed by availability, competing instructional demands, and instructor turnover. It would have been desirable but was not possible to balance instructor and facilitator assignments in a systematic way across conditions. Despite this constraint, we have no reason to suspect that the way in which these assignments were made affected the dependent variables.

Preparation for VTT Training

Training Course Selection

During previous research, we developed criteria and conducted training process analyses to identify and select courses to use in distance education research (Simpson, Pugh, & Parchman, 1990). Selection criteria were frequent convening, significant class size, no need for special equipment, and length of less than 1 week. We observed several Navy training courses, conducted a training analysis, and determined that the Supervisor's 3M Administration and Operations course would be a good candidate. 3M is a high-backlog, 4-day, lecture-based maintenance record-keeping course. It requires presentation of graphics, which must be annotated; has laboratories during which students fill out written forms, which must be reviewed by the instructor, who provides individual feedback to students; and requires written tests to be administered. Live 3M courses invariably call for considerable instructor-student interaction in the form of questions, answers, discussion, and miscellaneous administrative matters. The 3M course was selected because it (1) has a steady flow of students and would facilitate data collection and (2) is rich in terms of the training processes it requires and research results based on it generalize to other lecture-based Navy training courses.

Classroom Procedures

Classroom procedures were constrained by the audio/video equipment used, classroom design (both described later), and the requirement to conduct training and manage two classes simultaneously. The classroom had a stationary camera pointed at the instructor (who stood behind a lectern) and a second stationary camera, pointed at a white board to the instructor's left, which could be switched on to allow the instructor to write on the white board, but which was never used (instructors preferred to write instead on paper on the baseboard of an easel camera). Instructors had to restrict their movement left and right to remain in the picture frame. The easel camera was an effective alternative to a white board and proved superior in its ability to zoom, present color, and show three-dimensional objects.

No modifications were made to the content of lectures, classroom exercises, tests, or other classroom materials. VTT and live course length were identical. Viewgraphs used in the live class were cleaned up and converted to hard copy form to improve their appearance on TV displays.

Traditional instructor-student interaction procedures were modified for VTT. The instructor made seating charts of both classrooms and systematically alternated questions between classrooms. In some research conditions, the instructor could see students in the remote classroom on a TV monitor but not usually well enough to identify who was speaking. In all research conditions, students were required to identify self by name, pause to be recognized by the instructor, and then asked their question. The instructor would sometimes repeat a question before answering. In some conditions, students could not speak to the instructor.

Classes included laboratories during which students filled out written forms and received individual feedback on their answers from the instructor. In a live class, the instructor would stroll the classroom to provide help. This was impossible in the remote VTT class so the instructor had remote students send their work to him via camera, facsimile machine, or both and would talk to students individually using a telephone handset. In research conditions that did not allow remote students to speak to the instructor, they did not receive individual help; the instructor worked individually with students in the local classroom but only reviewed the correct answers on work sheets for the remote class.

Multiple-choice paper and pencil tests were administered and scored in the local classroom by the instructor; this was done in the remote classroom by the facilitator, and the results were transmitted back to the instructor in the originating classroom using the facsimile machine.

Instructor Training

Six different instructors delivered training in the VTT laboratory. All instructors had graduated from Navy instructor training school and were qualified to teach 3M. NPRDC research personnel worked closely with the first two instructors during an informal 1-week training period. Instructors were familiarized with the audio and video equipment and practiced equipment operation and classroom procedures. The total training period per instructor was approximately 2 days.

The two initial instructors subsequently trained the other four instructors who taught in the VTT laboratory. The training received by later instructors went more rapidly than that received by the initial instructors. It came as something of a revelation to us that instructors could become competent VTT instructors with about two days of informal training and practice and few days teaching in a VTT classroom. None of the instructors was given or had previously received training in camera presence, articulation, graphics production, or other skills of TV professionals.

VTT Laboratory

The VTT laboratory is described below in terms of equipment selection and classroom design.

Equipment Selection

TV cameras: Simulation requirements called for four different TV cameras in each classroom: (1) instructor, (2) easel camera, (3) class, and (4) auxiliary. We selected high-quality single-chip CCD color cameras for all applications. A Panasonic WV-D5100 camera with 12:1 zoom lens was used for the instructor and Panasonic WV-CL110 cameras with wide-angle lenses were used for class and auxiliary cameras. The WV-D5100 is widely used in audio-visual work and the WV-CL110 mainly in surveillance applications. Elmo easel cameras were used; the Elmo is a compact, dedicated, easel camera resembling an overhead projector. A multi-channel video switch was used to select which camera's signal to send to the other classroom.

TV displays and monitors: Large-size TV displays were required to present pictures to the class and smaller monitors to present pictures to single viewers (instructor and researchers). Most simulations required a single TV display, though some required two or even three. There was uncertainty about what size display to use. Many instructional TV systems use 25" TV displays, often several in a single classroom, though larger displays seem to be becoming more common.

Guidance on monitor size selection and on other aspects of the use of monitors in class is limited, as we noted in previous research (see Simpson, Pugh, & Parchman, 1990). We obtained 25", 35", and 45" displays and had students in two classes declare their preferences for Mitsubishi 35" tube or 45" rear-projection displays after 4 days of viewing them in parallel. Students preferred the larger display by a margin of about 8:1 and we subsequently used it as the main display in all simulations. Sony 13" TV monitors were used to present pictures to the instructor and researchers.

Audio system: We selected Shure AMS-8000 eight-channel audio mixers and AMS-22 low-profile sound-activated table microphones. The instructor wore a wired clip-on Shure model 839 lavalier microphone; the mixer channel for this microphone was modified so that the microphone was continuously on rather than sound activated. Each classroom was equipped with two audio mixers, whose combined output was fed via audio cable to a 75 watt public address system in the other classroom.

Other equipment: Each classroom was equipped with a telephone connected to the telephone in the other classroom via ring-down telephone circuit. Picking up one receiver caused the bell of the other telephone to ring and permitted talk between classrooms. Each classroom was equipped with a Panasonic UF-250 facsimile machine with its own line to the other classroom. Each classroom was also equipped with various other items of equipment, including TV monitor racks, camera hangers and mounts, tables and chairs, etc.

Classroom Design

Both classrooms were equipped with overhead fluorescent lights, which were modified by adding a dimmer switch and using tubes balanced for a color temperature of 3200 degrees Kelvin to assure that flesh tones would look natural on camera. No special lighting was used in classrooms; adjustable window blinds controlled the entry of external light. The front wall of each classroom was painted pale blue and cleared of clutter to provide a suitable backdrop on camera. Both classrooms were carpeted to reduce echoes and reverberation. Ceilings had acoustic tiles.

Classroom sizes were 30' by 30' (local) and 30' by 40' (remote). Both rooms provided ample space for arranging furniture and equipment. Figure 7 shows the floor plan of both classrooms. Students sat at 72" X 30" tables, with two chairs per table. Each table was equipped with a low-profile microphone. The tables were arranged in amphitheatre fashion so that all students would be seated within the 90-degree arc originating from the center of the 45" TV display; this assured that all students could view the primary TV display adequately. Two additional TV displays were located to the left of the primary display. In research conditions providing 2-way video, the 35" TV in the originating classroom was moved to the back of the classroom so that it could be used to display the remote class to the instructor.

The instructor's primary camera was suspended above the second row of tables. The class camera was located above and behind the 45" TV display. The instructor's auxiliary camera was suspended forward of the primary camera and to its right so that it covered an area that might be used for a white board; the auxiliary camera was never used during research. The instructor stood behind a lectern at the front of the classroom to the left of the primary TV display. On the table to his left were an easel camera and two 13" TV monitors; one monitor showed outgoing video and the other monitor was either unused or showed incoming video (in research conditions providing 2-way video). The table also held the facsimile machine and telephone handset.

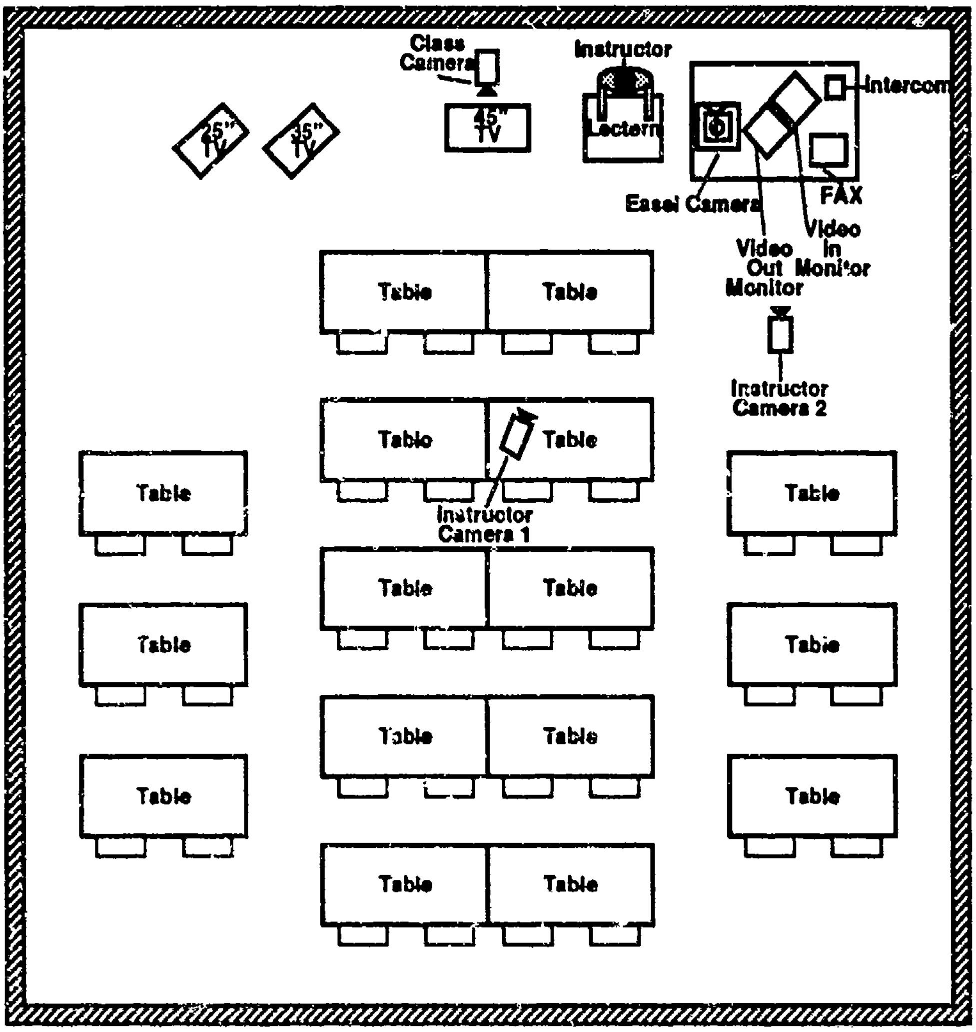

Figure 7. VTT classroom floor plan.

The video switch (a small panel with seven push buttons) was attached to the left side of the lectern so that the instructor could reach down and switch cameras with a single unobtrusive motion of the left hand. In most research conditions, the instructor used this switch to control which of the four cameras to switch on and in turn display on the 45" TV in the originating classroom and transmit to the remote classroom.

RESULTS

Overview

Research conditions 1, 2, 3, and 4 occurred throughout the 4-day course, but conditions 5, 6, and 7 occurred only during day 2. Many of the data collection instruments reflect the cumulative effect of the entire course, and, therefore, could not be used in determining the effects of conditions 5, 6, and 7. Comparisons of the effects of conditions 1, 2, 3, and 4 could be made using all forms of data; the first subsection makes these comparisons. The second subsection compares conditions 1, 5, 6, and 7 using the appropriate subset of data. No direct comparisons are made among conditions 2, 3, and 4 and conditions 5, 6, and 7, though inferences may be drawn by reference to condition 1, which is the common denominator in other comparisons.

As noted in the Method section, the study used conventional rather than compressed-bandwidth TV. If the experiment were replicated with compressed-bandwidth TV, any differences between live and VTT conditions might increase slightly, but no differences among VTT conditions would be expected.

Comparisons Among Conditions 1, 2, 3, and 4

Conditions are compared below based on (1) final examination, (2) course questionnaire, and (3) observations.

Final Examination

Table D-3 shows the raw final examination scores for all subjects in conditions 1, 2, 3, and 4 in local and remote classrooms. The data are summarized in bar graph form in Figure 8.

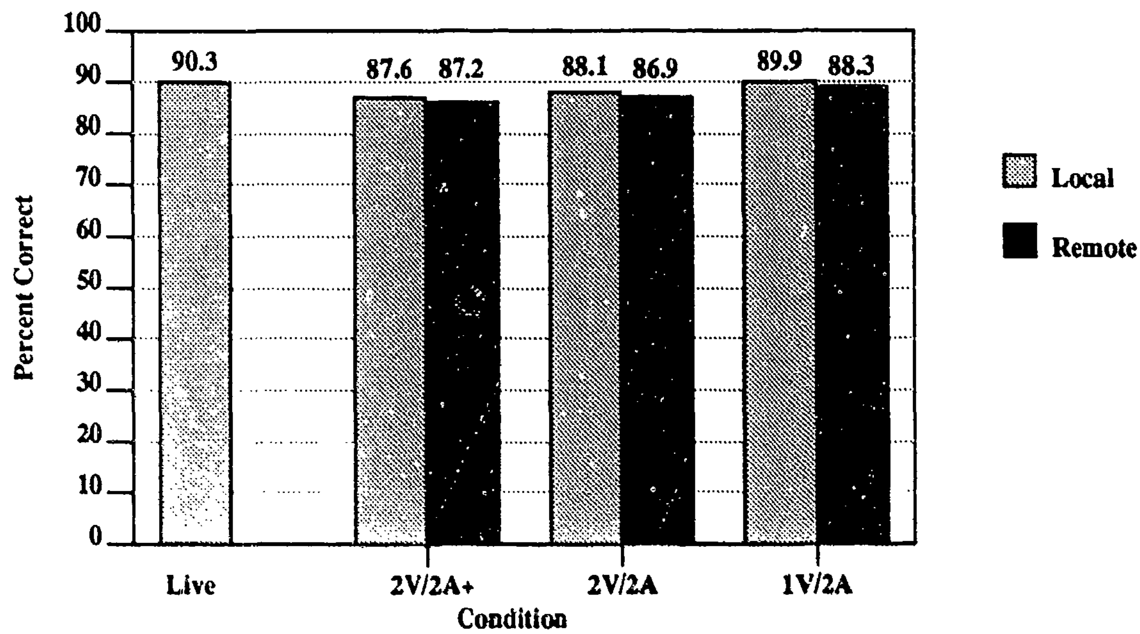

Figure 8. Bar graph of raw final examination scores for conditions 1, 2, 3, 4.

Student seniority varied with condition (see Table D-2) and might influence performance on the final examination and mask the effects of the independent variable. The data were analyzed using an hierarchical analysis of covariance (Cohen & Cohen, 1975; Overall & Spiegel, 1969). Seniority, the covariate, was found to have a significant effect on final examination performance, $F(1,418) = 34.64$, $p < .01$. Variance due to the covariate was removed in subsequent comparisons, which were made in the following order:

1. Live (condition 1) versus All VTT (conditions 2, 3, 4).

2. 1V/2A (condition 4) versus 2V/2A and 2V/2A+ (conditions 2, 3)

3. 2V/2A (condition 3) versus 2V/2A+ (condition 2).

4. Local classroom (across conditions 2, 3, 4) versus remote classroom (across conditions 2, 3, 4).

Table 3 summarizes the results of this analysis. The amount of variance accounted for by seniority was statistically significant and was by far the largest effect shown in Table 3.

Table 3

Hierarchical ANCOVA Results for Conditions 1, 2, 3, 4

Comparison	Variable 1	Mean 1	Variable 2	Mean 2	df	F	p
Live vs. all VTT (2, 3, 4)	Live	90.03	All VTT (2, 3, 4)	88.02	1,418	3.93	<.05
2V/2A & 2V/2A+ vs. 1V/2A	2V/2A & 2V/2A+	87.44	1V/2A	89.08	1,418	4.01	<.05
2V/2A vs. 2V/2A+	2V/2A	87.49	2V/2A+	87.40	1,418	< 1	NS
Local vs. Remote	Local	88.56	Remote	87.47	1,418	2.56	NS

The difference between Live and All VTT was small but statistically significant. Students in live classes scored about 2 points higher than VTT students but VTT should not be expected to degrade student performance in any meaningful way. This finding provides a stronger foundation for comparisons between live and VTT instruction than had existed. In previous research, we had been unable to use a live class as a control condition in assessing VTT, but had used instead the originating classroom in a VTT system (Simpson, Pugh, & Parchman, 1990) and found no significant performance difference between classes. However, a live class is not truly equivalent to an originating VTT class (e.g., class sizes differ, the instructor has to attend to video equipment, the remote class must be monitored, etc.).

The difference between 1-way video and 2-way video was small but statistically significant. Students in 1-way video classes scored about 1.5 points higher than students in 2-way video classes. This finding is counter-intuitive, as it would seem that 2-way video is a richer environment than 1-way video. There is no difference between these conditions from the students' point of view but there is from the instructor's. With 2-way video, the instructor can see the remote class but with 1-way video he or she cannot. A possible explanation for the difference is that 2-way video imposes additional burdens on the instructor, who must (1) allocate attention to the TV showing the remote class, (2) rely on visual cues from the remote class (e.g., raised hand) in a low-grade visual environment rather than on auditory cues to attract the instructor's attention, and (3) synthesize auditory and visual cues that are contradictory (location of the voice from the speaker is not in agreement with student image on the monitor). One-way video relieves the instructor of these burdens, although it renders him or her blind to the remote class.

The difference between single-channel 2-way video and multiple-channel 2-way video was not statistically significant.

The difference between local classroom and remote classroom was not statistically significant. This finding is consistent with our earlier research (Simpson, Pugh, & Parchman, 1990).

Course Questionnaire

Student attitudes were measured with a post-course questionnaire (Appendix B), which contained a series of statements to be rated, multiple-choice questions, and open-ended questions. The questionnaire was administered to all students taking courses at live, local VTT, and remote VTT classrooms.

Student Ratings. The statements to be rated fell into six categories (instructor, audiovisual aids, tests and homework, overall assessment of instructor and course, course content, form of instruction). Questions 1-21 were rated on a 5-point scale with a midpoint of 3. Questions 30-39 were rated on a 7-point scale with a midpoint of 4. Mean ratings were computed for local and remote classrooms in conditions 1-4. The majority of ratings on all items fell well above the midpoint on the rating scale; most students gave positive ratings to the dimension being measured. To assess statistical significance, each condition, local and remote, was compared with condition 1, live instruction, using a post hoc analysis of variance. Six comparisons were made for each of the 31 questions. No statistically significant differences were found in any of the comparisons. Only minor patterns were present in the data, as discussed below.

Table D-4 shows student ratings on statements relating to the instructor. Whether taking the course live or in one of the VTT conditions, students perceived instructor performance to be outstanding.

Table D-5 shows student ratings on statements relating to audiovisual aids. Ratings were high on all questions relating to video and graphics, but in 2V/2A (condition 3), remote, students gave lower ratings on questions 10 and 11, which relate to audio transmission loudness and clarity. In reviewing other data associated with this phase of data collection, we have reached the conclusion that these lower ratings reflect the unique audio problems experienced during early data collection and are not a general property of 2V/2A.

Table D-6 shows student ratings on statements relating to tests and homework. Ratings on question 15 were somewhat lower than on other questions, regardless of condition, but no other patterns are apparent in the data.

Table D-7 shows ratings on statements relating to overall assessment of instructor and course. There are no patterns of interest.

Table D-8 shows ratings on semantic differential items relating to course content. There appears to be a pattern throughout the data of students in VTT local classrooms giving slightly higher ratings than students in corresponding remote classrooms, though differences are small and not statistically significant and all ratings were high.

Table D-9 shows ratings on semantic differential items relating to form of instruction. There appears to be a pattern throughout the data of students in VTT local classrooms giving slightly higher ratings than students in corresponding remote classrooms, though differences are small and not statistically significant and all ratings are high.

Table D-10 shows student responses to question 22. The data are collapsed across VTT conditions and summarized graphically in Figure 9. Differences among group frequencies were analyzed using a chi-square test for goodness of fit, and differences among the three groups were found to be significant, (2 df) = 10.53, $p < .01$. The percentage of students who responded "yes" was highest in the live class, lower in VTT local classes, and lowest in VTT remote classes. Overall, however, the majority of students responded positively to the question.

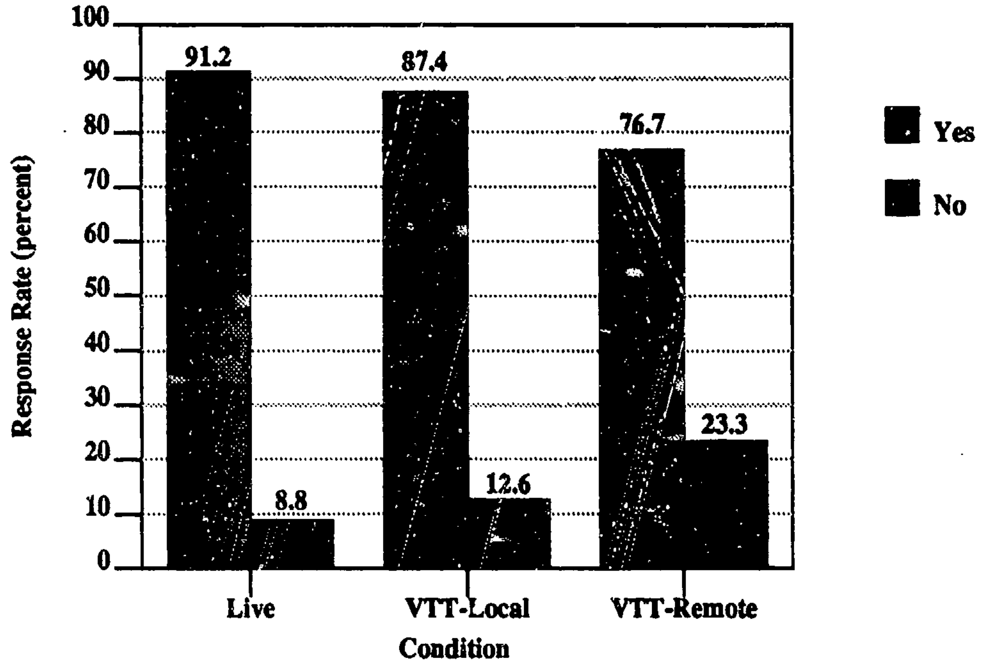

Figure 9. Student responses to question 22 (Did you talk to the instructor or ask any questions during the regular hours of this course?), collapsed across VTT conditions.

Table D-11 shows student responses to question 23. The data are collapsed across VTT conditions and summarized graphically in Figure 10. Differences among group frequencies were analyzed using a chi-square test for goodness of fit, and differences among the three groups were found to be significant, (4 df) = 26.87, $p < .001$. Most students felt either that VTT had no effect on opportunities to ask questions or provided more opportunities. However, in remote classes, overall, 17.7 percent of students felt that VTT had provided fewer opportunities.

Table D-12 shows student responses to question 28. The data are collapsed across VTT conditions and summarized graphically in Figure 11. Differences among group frequencies were analyzed using a chi-square test for goodness of fit, and differences among the three groups were found to be significant, (4 df) = 17.96, $p < .01$. Approximately 30 percent of students in local and remote classes expressed preference for traditional instruction; the majority either expressed no preference or preferred VTT. Interestingly, students in the remote class were about twice as likely to prefer VTT as students in the local class.

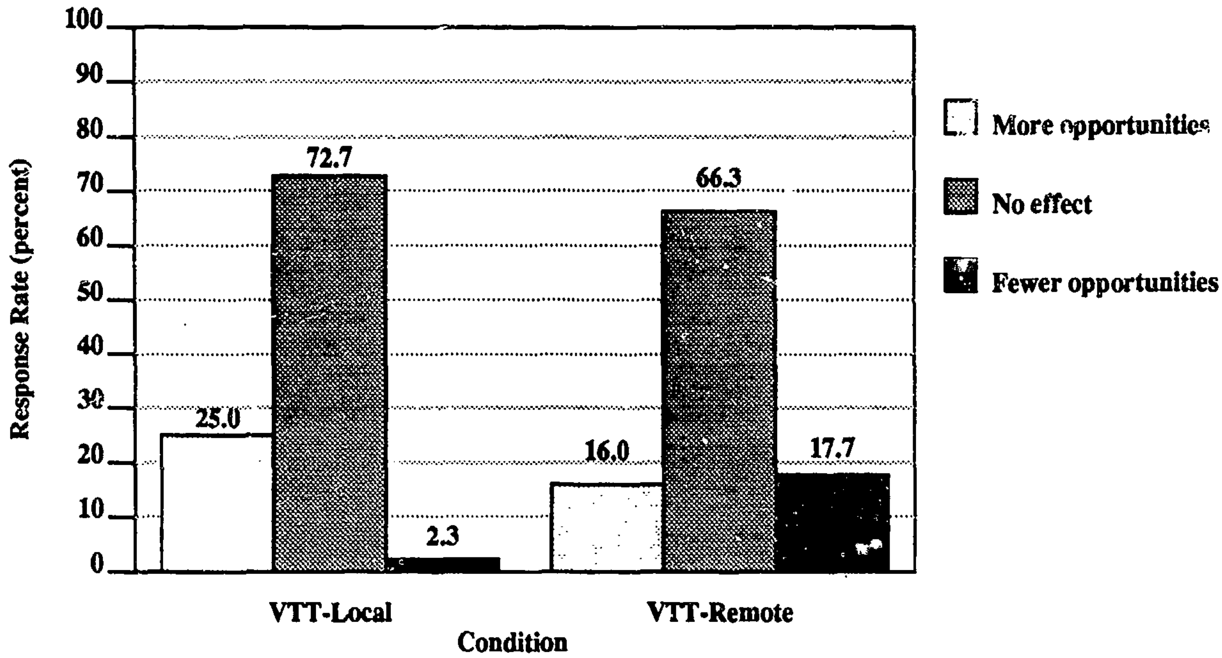

Figure 10. Student responses to question 23 (How did the VTT method of instruction affect your opportunities to talk to the instructor or ask questions, as compared to traditional methods of instruction?).

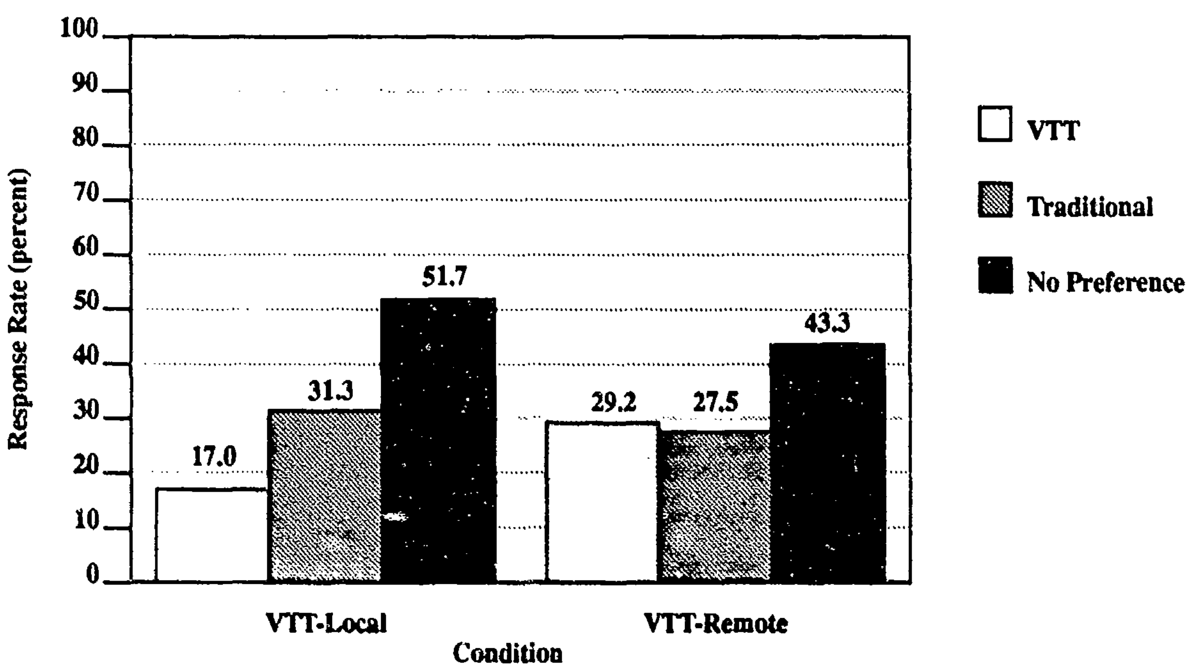

Figure 11. Student responses to question 28 (Which method of instruction would you have preferred for this course?).

Table D-13 shows student responses to question 29. The data are collapsed across VTT conditions and summarized graphically in Figure 12. Most students either felt that VTT had no effect on learning or improved learning. A chi-square goodness of fit analysis did not reveal any significant differences in frequency of choice of responses among the three groups of respondents.

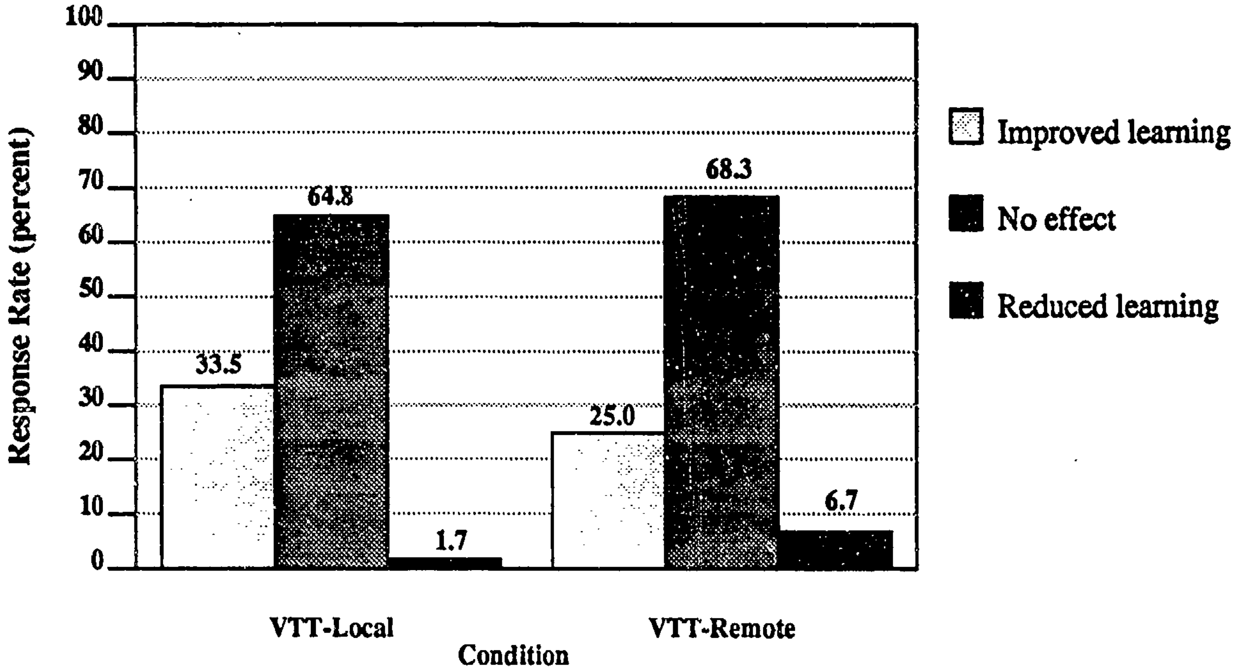

Figure 12. Student responses to question 29 (How did the participation of student at other site(s) affect your learning during this course?).

Student Comments. Comments were solicited from the 429 students in conditions 1, 2, 3, and 4 with three open-ended questions (40, 41, 42) relating to student likes and dislikes about the course and suggestions for improvements. The comments were exhaustively listed and then categorized for live instruction (condition 1) and VTT (conditions 2, 3, 4) in local and remote classrooms.

The breakdown of comments for question 40 (student likes) is shown in Table 4. The three most common comments related to course content, instructor, and audio-visual. The pattern of comments is similar for the three listing categories with two exceptions: (1) live and VTT local students were more likely than VTT remote students to comment on the instructor and (2) VTT remote students were more likely to comment on audio-visual than live or VTT local students.

The breakdown of comments for question 41 (student dislikes) is shown in Table 5. The four most common comments related to dry material, audio-visual, sound problems, and tests/quizzes/ homework. The pattern of comments is similar for the three listing categories with two exceptions: (1) live and VTT local students were more likely than VTT remote students to comment on dry material and (2) VTT remote students were more likely to comment on sound problems than live or VTT local students.

Table 4

**Student Responses to Question 40:
What did you like most about this course?
(Numbers are percentages.)**

Comment	Live (N = 40)	VTT Local (N = 158)	VTT Remote (N = 142)
Course content	45	44	45
Instructor	30	26	15
Audio-visual	5	11	22
Exercises/using manual	10	7	8
Classroom environment	3	6	1
Usage of time	5	4	4
Working with other students	3	1	6

The breakdown of comments for question 42 (student suggestions) is shown in Table 6. Note that (1) the majority of comments reflect VTT audio or video and (2) remote students made many more suggestions than local students. Remote students were probably more aware of VTT than local students because VTT deficiencies were more likely to affect them. The pattern of responses is similar for local and remote classrooms with two exceptions: (1) remote students were more likely than local students to suggest improving audio and (2) local students were more likely than remote students to express a desire to see the other class. Many students in both classrooms suggested that push-to-talk microphones should be used. The motivation appeared to be either that sound-activated microphones (1) resulted in unwanted sounds being generated (for example, fingers tapping on tables) and interfering with student understanding or (2) precluded private conversations between students.

Table 5

Student Responses to Question 41: What did you like least about this course? (Numbers are percentages.)

Comment	Live (N = 29)	VTT Local (N = 105)	VTT Remote (N = 118)
Dry material	28	25	12
Audio-visual	17	15	17
Sound problems	0	4	19
Tests/quizzes/homework	14	10	12
Not enough time	14	11	8
Course procedures/processes	0	7	10
Personal	7	5	11
Course organization	7	10	3
Classroom environment	14	9	3
Too much time	0	5	5

Table 6

Student Responses to Question 42: Discuss any suggestions you have for improving how video teletraining is used in this course. (Number are percentages.)

Comment	VTT Local (N = 49)	VTT Remote (N = 121)
Improve video	26	27
Improve audio	14	28
Show other class	31	17
Use push-to-talk mikes	12	17
Change procedures/processes	16	13

Observations

The instructors gained skill and confidence in the VTT classroom rapidly. All functioned effectively within a few hours and became comfortable and skilled before the camera in about 2 weeks.

The most consistent problem was with audio. Difficulties were encountered in setting mixer and PA system levels, preventing inadvertent transmission of noise, and controlling feedback. The heavy, gated lavalier microphone provided with the Shure mixer never operated satisfactorily and was eventually replaced with a lighter, ungated lavalier microphone.

It became obvious that there is a trade-off in providing students with sound-activated table microphones. On the positive side, these allow students to be heard simply by speaking; no button has to be pressed to activate the microphone. On the negative side, they preclude the possibility of private conversations between students since everything the student says will be heard, and they increase the likelihood of class disruptions. Everything a student says will be picked up by his or her microphone and broadcast over the public address system to the other class. Push-to-talk microphones would prevent such occurrences and allow more natural communication between students.

The originating classroom was controlled by the instructor and the remote classroom by his or her proxy, the facilitator, or in the facilitator's absence, the class leader. The facilitator handled administrative matters, maintained class order, operated equipment, administered and scored tests and acted as the instructor's eyes and ears in the remote class. The importance of the facilitator became obvious during periods of his absence when there would often be a lack of coordination between classes, technical problems might go unresolved, and the remote class would not run as smoothly. Moreover, the facilitator became increasingly important as video (and later audio) became degraded and the instructor had less direct information on what was happening in the remote class.

Analysis of classroom interaction analysis forms revealed that all classes spent over 95 percent of lecture time "on task" (i.e., performing class-related activities (Table D-14)). Live classes tended to discuss, talk, or read during lecture slightly more than VTT local or remote classes. This appears to be a result of VTT instructors making a sharper distinction between lecture and laboratory/discussion parts of classes (i.e., carefully separating different class processes such as lectures, discussion, and laboratories). During laboratories (Table D-15), VTT remote students spent more time talking with one another and less time discussing classroom activities with the instructor, but in other respects classroom interactions were very similar in live and VTT classes.

In debrief interviews, instructors expressed their preference for teaching in VTT classrooms that permitted 2-way video rather than 1-way video. It appeared to take instructors slightly longer to adapt to 1-way video than 2-way video. Instructors who had been teaching in 2-way video classrooms appeared to find the first week of teaching in 1-way video classrooms somewhat stressful. They may have felt that their control over the remote classroom was diminished because they could not see the remote students. However, by the end of the second week of teaching in 1-way video classrooms, the instructors had developed new ways of coping with the unseen class and had adjusted.

Comparisons Among Conditions 1, 5, 6, and 7

Conditions are compared below based on (1) day 3 quiz, (2) course questionnaire, and (3) observations.

Day 3 Quiz

Table D-16 shows the raw day 3 quiz scores for all subjects in conditions 1, 5, 6, and 7 in local and remote classrooms. The data are summarized graphically in Figure 13.

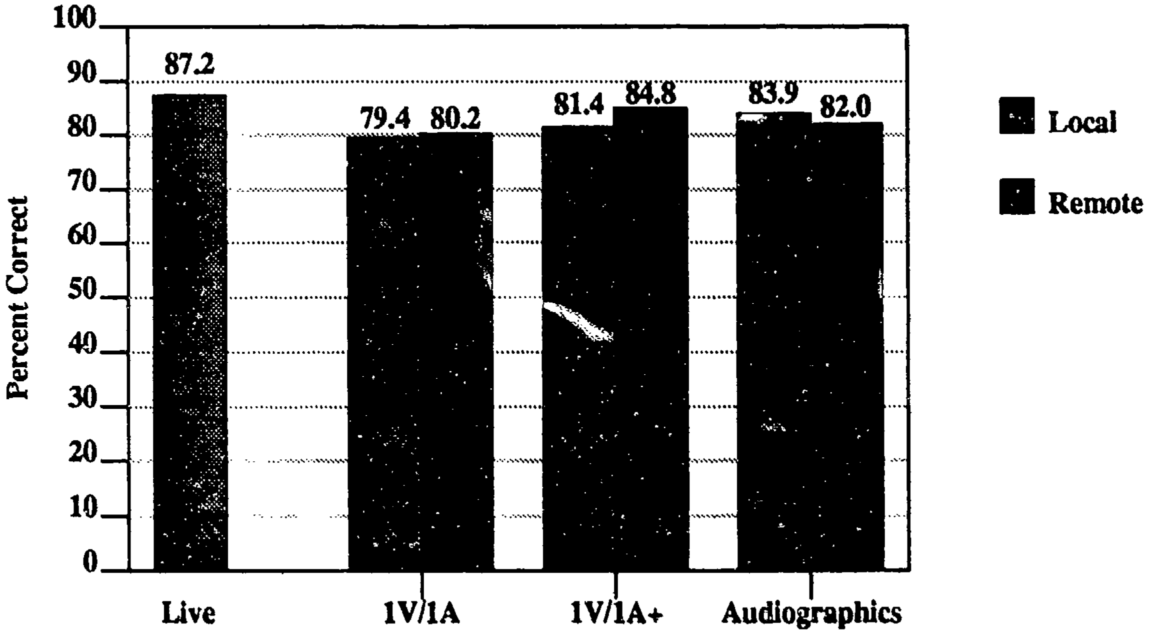

Figure 13. Bar graph of raw day 3 quiz scores for conditions 1, 5, 6, 7.

Student seniority varied with condition (see Table D-2) and might influence performance on the day 3 quiz and mask the effects of the independent variable. The data were analyzed using an hierarchical analysis of covariance (Cohen & Cohen, 1975; Overall & Spiegel, 1969). Seniority, the covariate, was found to have a significant effect on final examination performance, $F(1,358) = 4.72$, $p < .05$. Variance due to the covariate was removed in subsequent comparisons, which were made in the following order:

1. Live (condition 1) versus All VTT (conditions 5, 6, 7).

2. Audiographics (condition 7) versus 1V/1A and 1V/1A+ (conditions 5, 6).

3. 1V/1A (condition 5) versus 1V/1A+ (condition 6).

4. 4. Local classroom (across conditions 5, 6, 7) versus remote classroom (across conditions 5, 6, 7).

Table 7 summarizes the results of this analysis. The amount of variance accounted for by seniority was statistically significant but smaller than the comparable effect in Table 3. The difference is probably the result of the reduced reliability of the 15-item quiz underlying Table 7 as compared to the 50-item final examination underlying Table 3.

Table 7

Hierarchical ANCOVA Results for Conditions 1, 5, 6, 7

Comparison	Variable 1	Mean 1	Variable 2	Mean 2	df	F	p
Live vs. all VTT (5, 6, 7)	Live	87.24	All VTT (5, 6, 7)	82.35	1,358	4.81	<.05
Audiographics vs. 1V/1A & 1V/1A+	Audiographics	82.89	1V/1A & 1V/1A+	82.04	1,358	< 1	NS
1V/1A vs. 1V/1A+	1V/1A	79.78	1V/1A+	83.10	1,358	1.89	NS
Local vs. Remote	Local	81.89	Remote	82.81	1,358	< 1	NS

The difference between Live and All VTT was statistically significant. Students in live classes scored about 5 points higher than VTT students, a substantial difference. None of the remaining comparisons produced statistically significant results. These findings suggest that audiographics and 1-way video are not adequate substitutes for live instruction. However, more refined audiographics and 1-way video simulations might produce better results.

Course Questionnaire

Students in conditions 5, 6, and 7 completed the same questionnaire as students in conditions 1, 2, 3, and 4. However, conditions 5, 6, and 7 occurred only during day 2, so comments reflect the surrounding treatment (equivalent to condition 4), which occurred on days 1, 3, and 4 as well as day 2's experimental treatment. Nonetheless, many student comments made clear and unambiguous references to day 2's experimental treatment in responding to question 41 (student dislikes), which are revealing. Four students in condition 5 and five in condition 6 stated that what they disliked was not being able to speak to the instructor. Three students in condition 7 disliked not being able to see the instructor.

Observations

The instructors became more proficient with practice, but one of the instructors never appeared comfortable while teaching in research conditions 5, 6, and 7 and expressed dissatisfaction with the VTT method of instructional delivery.

The effects of audio problems were compounded when students in the receiving classroom were unable to communicate with the instructor. There were a few occasions when audio problems made it difficult to understand the instructor but, since there was no way to communicate with him or her, no corrective action could be taken.

Students expressed frustration during conditions 5 and 6 when they were unable to speak to the instructor. We observed an increase in the noise level in the classroom as students began addressing questions to one another and carrying on discussions in class during the lecture. In addition, students were observed to take greater liberties in terms of moving in and out of the classroom, taking breaks, performing written exercises and, in general, disconnecting somewhat from the originating classroom.

Analysis of classroom interaction analysis forms revealed that all classes spent over 90 percent of lecture time "on task" (i.e., performing class-related activities (Table D-17)). Live classes tended to discuss or read during lecture slightly more than VTT local or remote classes. During laboratories (Table D-18), VTT remote students spent more time "off task" than students in live classes. Students in conditions 5, 6, and 7 also spent more time off task than students in conditions 2, 3, and 4 (see Table D-15). The percentage of students off-task in conditions 5, 6, and 7 was highest for remote classes but local classes were also affected. Conditions 5, 6, and 7 limited the amount and quality of communication between students and instructor, and this evidently made group activities more difficult to manage, resulting in inefficient use of class time. Informal breaks were permitted during the laboratories, and when 2-way communication was limited, the instructor appeared to have difficulty controlling student presence in the classroom; students were absent from the room a relatively high percentage of time in VTT conditions.

DISCUSSION

The results are based on 6 months of data collection with a large number of subjects, but with a single lecture-based Navy training course. The results should generalize to lecture-based courses and to the lecture and discussion portions of other types of Navy courses. The results indicate that VTT in several different forms was effective both in terms of student performance and student and instructor acceptance. Type of VTT technology did influence student performance and attitudes, but had a far smaller effect than seniority. Instructors had definite preferences for certain VTT technologies, but these did not appear to impact their classroom performance.

The most successful VTT technologies were fully-interactive: 2V/2A+, 2V/2A, 1V/2A. Student performance was comparable with live and VTT instruction using 2V/2A+, 2V/2A, and 1V/2A. Using 2-way video does not appear to improve student performance as compared to 1-way video, but instructors prefer 2-way video and students expressed the desire to see their cohorts in other classes, which requires 2-way video.

The least successful VTT technologies were partially-interactive: 1V/1A, 1V/1A+, audiographics. Student test performance was poorer with VTT systems that restricted remote students' ability to converse with or see the instructor and the performance decrement was evident in both local and remote classrooms. Evidence suggests that student acceptance of partially-interactive VTT was lower than with fully-interactive VTT. Similar results would be expected with videotaped instruction because of its similarity to 1V/1A. Students adapted to compensate for the shortcomings of VTT technologies they were trained with. For example, when students in remote classrooms were unable to speak to the instructor, they increased their level of interaction with one another. Observing their compensatory behavior reminded us that much of Navy training occurs under difficult conditions and that Navy personnel are generally tolerant and try to make the best of the situation.

Partially-interactive technologies did not work as well as fully-interactive technologies, but they did work; student test performance decrements resulting from the use of partially-interactive technologies were small. Because these technologies cost so much less than fully-interactive technologies, they should be considered for use where cost is a major consideration.

Our observations suggest that good-quality audio is more critical to training success than good quality video; the student can learn from a lecture without observing the instructor, but can seldom learn from observing without hearing the lecture. The most serious shortcoming of the VTT systems we simulated was audio. The audio problem is multi-dimensional and has classroom design, hardware selection, and procedural elements. Additional work needs to be done to refine the audio systems and procedures used in VTT.

RECOMMENDATIONS

1. The Chief of Naval Education and Training and the Naval Education and Training Program Management Support Activity should continue efforts to refine the CNET VTT network.

2. The Chief of Naval Education and Training and the Naval Education and Training Program Management Support Activity should analyze the feasibility and cost-effectiveness of extending the architecture of the CNET VTT network using VTT technologies such as 1-way video with 2-way audio and 1-way video with 1-way audio.

3. The Chief of Naval Education and Training and the Naval Education and Training Program Management and Support Activity should originate Problem Description and Need Justifications to continue the investigation of the applicability of VTT beyond lecture-based courses (e.g., in courses using "hands-on" laboratories, small-group, and other training processes).

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APPENDIX A

STUDENT SURVEY

STUDENT SURVEY
ADMINISTRATION AND OPERATION OF SHIPBOARD 3M SYSTEMS
J-500-0025

Date:__________________ Rate____________ Room No.________

Name________________________________ SSN(opt)_________________

PLEASE CIRCLE THE LETTER FOR THE MOST APPROPRIATE ANSWER

1. Did you request this course of instruction?

   A. Yes B. No

2. Have you attended this course within the past 2 years?

   A. Yes B. No If yes, where?______________

3. Have you had any previous SNAP II experience?

   A. Yes B. No

4. What is your current 3M PQS qualification level?
   a. Maintenance Person (3M-301)
   b. Work Center Supervisor (3M-302)
   c. Division Officer (3M-303)
   d. Departmental Assistant (3M-304)
   e. Department Head (3M-305)
   f. 3M Coordinator (3M-306)
   g. None

5. What is your current assignment?

   a. Maintenance Person
   b. Work Center Supervisor
   c. Group Supervisor
   d. Division Officer
   e. Departmental 3M Assistant
   e. Department Head
   f. 3M coordinator
   g. 3M inspector
   h. None

6. What position will you be going to upon completion of this course?

   a. Maintenance Person
   b. Work Center Supervisor
   c. Group Supervisor
   d. Division Officer
   e. Departmental 3M Assistant
   e. Department Head
   f. 3M coordinator
   g. 3M inspector
   h. Unknown

FOR OFFICE USE ONLY

Quiz One____________________
Quiz Two____________________
Quiz Three__________________
FINAL GRADE__________________

APPENDIX B

STUDENT COURSE EVALUATION QUESTIONNAIRE

1. Name ______________ ______ ______________ ______
First MI Last Rate

2. Today's date _____ /_____ /_____

3. Course title
- [ ] a. 3M Admin/Ops
- [ ] b. Safety Officer
- [ ] c. Safety Petty Officer
- [ ] d. Other (specify) ______________________

On the last page, there is room to comment on specific areas of concern. Please use this space to clarify how improvement can be made.

Section 1: Course Evaluation

*For each of the following statements (1 through 21), check the appropriate box corresponding to a scale of **1** (unsatisfactory) through **5** (outstanding), with **3** being average. Leave any statements that do not apply to this course blank.*

Instructor	Unsatisfactory → Outstanding (Average = 3)				
1. Instructor prepared for class	1☐	2☐	3☐	4☐	5☐
2. Instructor presented lessons clearly	1☐	2☐	3☐	4☐	5☐
3. Instructor answered student questions	1☐	2☐	3☐	4☐	5☐
4. Instructor encouraged class participation	1☐	2☐	3☐	4☐	5☐
5. Instructor was available for individual assistance outside of class	1☐	2☐	3☐	4☐	5☐
6. Instructor treated students fairly	1☐	2☐	3☐	4☐	5☐
Audio-Visual Aids					
7. Video screen was large enough to be seen	1☐	2☐	3☐	4☐	5☐
8. Video screen was close enough to be seen	1☐	2☐	3☐	4☐	5☐
9. Image on video screen was clear	1☐	2☐	3☐	4☐	5☐
10. Audio transmission was loud enough to hear instructor's voice	1☐	2☐	3☐	4☐	5☐
11. Audio transmission was clear enough to hear what the instructor said	1☐	2☐	3☐	4☐	5☐
12. Graphics/Slides/Transparencies on TV were readable	1☐	2☐	3☐	4☐	5☐
13. Television was in working order	1☐	2☐	3☐	4☐	5☐
14. Your microphone was in working order	1☐	2☐	3☐	4☐	5☐
Tests/Homework					
15. Test questions were clearly written	1☐	2☐	3☐	4☐	5☐
16. Test questions were directly related to course	1☐	2☐	3☐	4☐	5☐
17. Test answers were graded fairly	1☐	2☐	3☐	4☐	5☐
18. Homework assignments were understandable	1☐	2☐	3☐	4☐	5☐
19. Homework assignments were directly related to course	1☐	2☐	3☐	4☐	5☐
Overall					
20. Comparison of this instructor to other Navy instructors that have taught you in the past	1☐	2☐	3☐	4☐	5☐
21. Comparison of this course to other Navy courses that you have taken in the past	1☐	2☐	3☐	4☐	5☐

Section 2: Instructor-Student Interaction

22. Did you talk to the instructor or ask any questions during the regular hours of this course?

- ☐ a. Yes
- ☐ b. No

23. How did the video tele-training method of instruction affect your opportunities to talk to the instructor or ask questions, as compared to traditional methods of instruction?

- ☐ a. More opportunities
- ☐ b. No effect on opportunities
- ☐ c. Fewer opportunities

24. Were there adequate opportunities for remedial instruction outside of the regular hours of this course?

- ☐ a.Yes
- ☐ b. No
- ☐ c. Remedial instruction was not necessary for this course.

25. Did you attend any remedial instruction periods?

- ☐ a. Yes
- ☐ b. No

Answer questions 26 and 27 only if you answered <u>yes</u> to question 25.

26. From whom did you obtain the remedial instruction?

- ☐ a. Instructor via video tele-training
- ☐ b. Instructor who was physically present in the same room
- ☐ c. Other (specify) ______________________________

27. How may hours of remedial instruction did you receive? ____________

Section 3: Student Comments

28. Which method of instruction would you have preferred for this course?

- ☐ a. Video tele-training where instructor is on TV
- ☐ b. Traditional methods of instruction where instructor is physically present in the classroom
- ☐ c. Indifferent between video tele-training and traditional methods of instruction

29. How did the participation of students at other site(s) affect your learning during this course?

- ☐ a. Improved learning
- ☐ b. No effect on learning
- ☐ c. Reduced learning

Section 3: Overall Impressions

Content of Course:

*DIRECTIONS: Thinking only of the content of the course, place an **X** in the one space of the seven between each adjective pair that best describes your opinion of the content of this course. The closer you place your **X** toward one adjective or the other, the more you think the adjective better describes the course content than the other.*

EXAMPLE: *If you think the content of this course was very meaningful, you would place an **X** in the space closest to that adjective.*

meaningful |___|___|___|___|___|___|___| meaningless

CONTENT OF THIS COURSE

No.									
30.	interesting	___	___	___	___	___	___	___	boring
31.	important	___	___	___	___	___	___	___	unimportant
32.	powerful	___	___	___	___	___	___	___	weak
33.	worthless	___	___	___	___	___	___	___	valuable
34.	good	___	___	___	___	___	___	___	bad

Form of Instruction:

*DIRECTIONS: Now thinking only of the form of instruction, place an **X** in the one space of the seven between each adjective pair that best describes what you think the form of instruction was like in this course. The closer you place the **X** toward one adjective or the other, the more you think the adjective better describes the form of instruction than the other.*

FORM OF INSTRUCTION

No.									
35.	good	___	___	___	___	___	___	___	bad
36.	weak	___	___	___	___	___	___	___	powerful
37.	annoying	___	___	___	___	___	___	___	pleasing
38.	successful	___	___	___	___	___	___	___	unsuccessful
39.	negative	___	___	___	___	___	___	___	positive

40. What did you like most about this course?

41. What did you like least about this course?

42. Discuss any suggestions that you have for improving how video tele-training is used in this course.

Section 4: Safety

43. Did lessons include safety where applicable (Safety as it applies to your job)?.

- [ ] Yes
- * [ ] No
- [ ] See Remarks

44. Did instructor(s) adequately cover safety items prior to conducting performance labs?

- [ ] Yes
- * [ ] No
- [ ] See Remarks

45. Was safety a primary consideration of the instructor(s)?

- [ ] Yes
- * [ ] No
- [ ] See Remarks

46. Was the classroom/laboratory equipment always safe for use?

- [ ] Yes
- * [ ] No
- [ ] See Remarks

* *Please comment in space provided below. If more space is needed, please use additional sheets.*

Section 3: Overall Impressions (continued)

43.Comment on usefulness and adequacy of the course content:. ____________________________

____

____

____

____

44. Comment on instructor preparedness and presentation: ____________________________

____

____

____

____

45. Comment on adequacy of training aids: ____________________________

____

____

____

____

46. Comment on appropriateness of the exams: ____________________________

____

____

____

____

Section 4: Safety

47. Did lessons include safety where applicable (Safety as applies to your job)?.

☐ Yes ☐ No ☐ See Remarks

48. Did instructor(s) adequately cover safety items prior to conducting performance labs?

☐ Yes ☐ No ☐ See Remarks

49. Was safety a primary consideration of the instructor(s)?

☐ Yes ☐ No ☐ See Remarks

50. Was the classroom/laboratory equipment always safe for use?

☐ Yes ☐ No ☐ See Remarks

Comment on safety: ____________________________

____

____

____

____

APPENDIX C

CLASSROOM INTERACTION ANALYSIS FORM

Classroom Interaction Analysis Form

Record 5 Students at 2 minute intervals

	ON TASK						OFF TASK		
Obser Time	Lect I→Ss	Class Discussion I=S	Talking S=S	Reading Lesson	Questions	Other (Desc.)	Talk S=S	"Day Dream"	Other (Desc.)
2									
4									
6									
8									
10									
12									
14									
16									
18									
20									
22									
24									
26									
28									
30									
32									
34									
36									
38									
40									
42									
44									
46									
48									
50									
52									
54									
56									
58									
60									

Date ____________ Hour ____________ Class ______________________________

Observer ______________________ ☐ First Deck ☐ Second Deck

APPENDIX D

ADDITIONAL TABLES

ADDITIONAL TABLES

Table D-1

Class Size as a Function of Research Condition and Classroom

Research Condition	Local Mean	Local Total *N*	Remote Mean	Remote Total *N*
1	19.7	59	N/A	N/A
2	20.0	60	19.0	57
3	20.3	61	20.3	61
4	22.0	66	21.7	65
5	16.0	32	15.5	31
6	22.3	67	22.7	68
7	18.7	56	20.0	60

Table D-2

Class Seniority as a Function of Research Condition and Classroom

Research Condition	Local Mean	Local SD	Remote Mean	Remote SD
1	2.42	1.12	N/A	N/A
2	2.53	1.33	2.53	1.15
3	2.28	1.13	2.67	1.15
4	2.51	1.01	2.40	1.09
5	2.28	0.89	2.10	0.94
6	2.24	1.18	2.40	1.05
7	2.43	1.13	2.42	1.08

Table D-3

Raw Final Examination Scores for Conditions 1, 2, 3, 4

Class Seniority as a Function of Research Condition and Classroom

Research Condition	Local Mean	Local SD	Remote Mean	Remote SD
Live	90.03	7.53	N/A	N/A
2V/2A+	87.56	7.89	87.23	10.35
2V/2A	88.10	9.17	86.89	7.65
1V/2A	89.91	5.66	88.25	7.51

Table D-4

Student Attitude Measures on Statements Relating to Instructor (Scale 1-5)

Question	Live	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
1. Instructor prepared for class.	4.7	4.5	4.5	4.6	4.5	4.7	4.7
2. Instructor presented lessons clearly.	4.5	4.4	4.3	4.5	4.3	4.6	4.5
3. Instructor answered student questions.	4.7	4.6	4.4	4.6	4.5	4.6	4.7
4. Instructor encouraged student participation.	4.7	4.5	4.3	4.6	4.5	4.5	4.6
5. Instructor was available for individual assistance outside of class.	4.3	4.4	4.1	4.3	4.0	4.6	4.5
6. Instructor treated students fairly.	4.7	4.7	4.5	4.6	4.5	4.7	4.7

Table D-5

Student Attitude Measures on Statements Relating to Audiovisual Aids (Scale 1-5)

Question	Live	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
7. Video screen was large enough to be seen.	4.4	4.5	4.4	4.4	4.4	4.6	4.7
8. Video screen was close enough to be seen.	4.3	4.5	4.4	4.4	4.4	4.6	4.6
9. Image on video screen was clear.	4.0	4.3	4.4	4.0	4.2	4.4	4.7
10. Audio transmission was loud enough to hear instructor's voice.	N/A	4.7	4.4	4.3	3.6	4.6	4.4
11. Audio transmission was clear enough to hear what the instructor said.	N/A	4.7	4.3	4.4	3.7	4.6	4.5
12. Graphics/Slides/Transparencies on TV were readable.	4.1	4.3	4.4	4.4	4.3	4.4	4.6
13. Television was in working order.	4.7	4.7	4.6	4.5	4.5	4.6	4.7
14. Your microphone was in working order.	N/A	4.7	4.5	4.4	4.2	4.7	4.7

Table D-6

Student Attitude Measures on Statements Relating to Tests and Homework (Scale 1-5)

Question	Live	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
15. Test questions were clearly written.	3.9	4.0	3.9	4.0	3.7	4.1	4.4
16. Test questions were directly related to course.	4.4	4.5	4.4	4.3	4.3	4.5	4.6
17. Test answers were graded fairly.	4.5	4.5	4.2	4.5	4.3	4.5	4.7
18. Homework assignments were understandable.	4.2	4.2	4.0	4.3	4.1	4.3	4.3
19. Homework assignments were directly related to course.	4.3	4.4	4.3	4.3	4.2	4.4	4.5

Table D-7

Student Attitude Measures on Statements Relating to Overall Assessment of Instructor and Course (Scale 1-5)

Question	Live	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
20. Comparison of instructor to others that have taught you in the past.	4.2	4.3	4.0	4.3	4.1	4.3	4.3
21. Comparison of this course to other Navy courses that you have taken in the past.	3.9	4.1	3.9	4.0	4.0	4.1	4.0

Table D-8

Semantic Differential Responses Relating to Course Content (Scale 1-7)

Question	Live	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
30.(interest)	5.1	4.8	4.6	5.3	5.3	5.6	4.7
31.(importance)	6.6	6.5	6.1	6.5	6.5	6.6	6.3
32.(power)	5.4	5.3	4.9	5.5	5.4	5.5	5.1
33.(value)	6.1	6.1	5.8	6.4	6.3	6.4	6.1
34.(goodness)	6.3	6.2	5.9	6.3	6.3	6.4	6.1

Table D-9

Semantic Differential Responses Relating to Form of Instruction (Scale 1-7)

Question	Live	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
35.(goodness)	6.3	5.9	5.8	6.3	6.0	6.4	6.1
36.(strength)	5.6	5.4	5.0	5.9	5.5	5.7	5.2
37.(pleasantness)	5.6	5.2	4.9	5.6	5.4	5.7	5.2
38.(success)	6.1	5.8	5.7	6.3	6.0	6.2	5.8
39.(positiveness)	6.1	5.9	5.6	6.2	6.0	6.2	5.8

Table D-10

Student Responses to Question 22:
Did you talk to the instructor or ask any questions during the regular hours of this course?
(Numbers are percentages.)

Response	Live	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
Yes	91.2	90.6	75.8	88.3	83.6	83.1	70.2
No	8.8	9.4	24.2	11.7	16.4	16.9	29.8

Table D-11

Student Responses to Question 23:
How did the VTT method of instruction affect your opportunities to talk to the instructor or ask questions, as compared to traditional methods of instruction?
(Numbers are percentages.)

Response	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
More opportunities	24.2	25.4	20.3	11.5	30.9	10.5
No effect on opportunities	72.6	68.3	76.3	65.6	69.1	64.9
Fewer opportunities	3.2	6.3	3.4	23.0	0.0	24.6

Table D-12

Student Responses to Question 28:
Which method of instruction would you have preferred for this course?
(Numbers are percentages.)

Response	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
VTT	17.7	41.3	20.7	18.3	12.5	27.3
Traditional	33.9	20.6	25.6	30.0	33.9	32.7
No preference	48.4	38.1	53.4	51.7	53.6	40.0

Table D-13

Student Responses to Question 29:
How did the participation of student at other site(s) affect your learning during this course?
(Numbers are percentages)

Response	2V/2A+ Local	2V/2A+ Remote	2V/2A Local	2V/2A Remote	1V/2A Local	1V/2A Remote
Improved learning	22.2	22.2	32.7	27.9	39.3	25.0
No effect on learning	74.6	71.4	60.0	63.9	58.9	69.6
Reduced learning	3.2	6.3	0.0	8.2	1.8	5.4

Table D-14

Interaction Analysis Summary for Lectures (Conditions 1, 2, 3, 4)

Events	Live	All VTT Local	All VTT Remote
On-task			
Lecture	91.9	99.2	99.4
Discussion	3.3	0.0	0.1
Talking	0.7	0.0	0.0
Reading	2.2	0.0	0.0
Other	0.0	0.0	0.0
Subtotals	98.1	99.2	99.5
Off-task			
Talking	0.9	0.4	0.1
Daydreaming	1.0	0.3	0.3
Absent room	0.1	0.1	0.1
Subtotals	2.0	0.8	0.5

Table D-15

Interaction Analysis Summary for Labs (Conditions 1, 2, 3, 4)

Events	Live	All VTT Local	All VTT Remote
On-task			
Lecture	0.2	0.0	0.0
Discussion	13.0	3.7	3.9
Talking	33.2	38.7	51.8
Reading	38.5	43.6	28.8
Other	1.1	0.0	0.0
Subtotals	86.0	86.0	84.5
Off-task			
Events			
Talking	2.9	2.5	1.2
Daydreaming	8.4	6.3	5.3
Absent room	2.9	5.2	9.1
Subtotals	14.2	14.0	15.6

Table D-16

Raw Day 3 Quiz Scores for Conditions 1, 5, 6, 7

Research Conditions	Local Mean	Local SD	Remote Mean	Remote SD
Live	87.24	12.63	N/A	N/A
1V/1A	79.35	16.27	80.21	17.17
1V/1A+	81.41	17.05	84.82	14.69
Audiographics	83.88	12.61	81.95	16.14

Table D-17

Interaction Analysis Summary for Lectures (Conditions 1, 5, 6, 7)

Events	Live	All VTT Local	All VTT Local
On-task			
Lecture	91.9	98.5	95.3
Discussion	3.3	0.0	0.0
Talking	0.7	0.0	2.9
Reading	2.2	0.0	0.1
Other			
Subtotals	98.1	98.5	98.3
Off-task			
Talking	0.9	0.1	0.3
Daydreaming	1.0	0.7	0.1
Absent room	0.1	0.7	1.3
Subtotals	2.0	1.5	1.7

Table D-18

Interaction Analysis Summary for Labs (Conditions 1, 5, 6, 7)

Events	Live	All VTT Local	All VTT Local
On-task			
Lecture	0.2	0.0	0.0
Discussion	13.0	7.4	3.2
Talking	33.2	31.0	33.7
Reading	38.5	41.2	36.5
Other	1.1	0.0	0.0
Subtotals	86.0	79.6	73.4
Off-task			
Talking	2.9	3.2	6.5
Daydreaming	8.4	4.1	7.6
Absent room	2.9	12.9	12.5
Subtotals	14.2	20.3	26.6

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