Technical Report 1095

Training Through Distance Learning: An Assessment of Research Findings

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19991004 213

June 1999

United States Army Research Institute for the Behavioral and Social Sciences

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DTIC QUALITY INSPECTED 4

U.S. Army Research Institute for the Behavioral and Social Sciences

A Directorate of the U.S. Total Army Personnel Command

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REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) June 1999	2. REPORT TYPE Final	3. DATES COVERED (from. . . to) Nov 1998-Feb 1999
4. TITLE AND SUBTITLE Training Through Distance Learning: An Assessment of Research Findings		5a. CONTRACT OR GRANT NUMBER 5b. PROGRAM ELEMENT NUMBER PR: 6330077
6. AUTHOR(S) Robert A. Wisher (U.S. Army Research Institute); Matthew V. Champagne, Jennifer L. Pawluk, and Angela Eaton (Rensselaer Polytechnic Institute); David M. Thornton (George Mason University); and Christina K. Curnow (George Washington University)		5c. PROJECT NUMBER PE: A792 5d. TASK NUMBER 208 5e. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: TAPC-ARI-II 5001 Eisenhower Avenue Alexandria, VA 22333-5600		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, VA 22333-5600		10. MONITOR ACRONYM ARI 11. MONITOR REPORT NUMBER Technical Report 1095

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 words)*:

This report offers a review of the literature on the effectiveness of distance learning as applied to training. Most research in distance learning was found to be anecdotal, focusing on education rather than training. When effectiveness was measured, it was usually not supported by strong experimental or quasi-experimental designs, and comparative results (such as to the classroom) were reported only one-third of the time. When data were reported, there were analytic problems and errors in reporting which were often overlooked by researchers. An assessment of the completeness of information in reporting course design and instructional techniques in the literature showed 40% of the studies did not mention course design or conversion and 25% did not mention instructional techniques. When distance learning was demonstrated to be effective, it was difficult to resolve why it was effective: the effort in course design or reconversion, the instructional techniques used, or the methods of communication (technology) employed. Suggestions for improving evaluations are offered.

15. SUBJECT TERMS

distance learning, training, evaluation, distributed learning, learning style, training effectiveness, cost effectiveness, research methods, experimental design

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	63	Dr. Robert A. Wisher (703) 617-5540

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June 1999

Army Project Number
2O363007A792

Personnel Performance and Training

Approved for public release; distribution is unlimited.

FOREWORD

The U.S. Army Research Institute is examining the use of distance learning technologies for use by soldiers in an "on demand" environment, where training becomes more soldier centered rather than classroom based. An early part of the work involves a thorough assessment of the distance learning research literature as it pertains to training.

A goal of the TRAINTODAY project is to determine whether it is better to train a particular task up-front in the classroom or just-in-time in the field. Since the application of distance learning is fundamental to this project, an important first step was to understand the learning that it mediates. A thorough assessment of the literature in distance learning, specifically as it applies to training rather than education, was required. The results of this assessment were briefed to BG Jon Root and members of the U.S. Army Reserve Distance Learning Futures Group on 23 January 1999. These findings will influence the incorporation of stronger research designs into the TRAINTODAY project.

Zita M. Simutis

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Technical Director

TRAINING THROUGH DISTANCE LEARNING: AN ASSESSMENT OF RESEARCH FINDINGS

EXECUTIVE SUMMARY

Research Requirement:

The Army has an ambitious plan to convert over 500 courses to a distance learning format, delivering training to a soldier when needed -- in unit learning centers, at the job site, or in their residence. In anticipation of this changing training environment, the U.S. Army Research Institute initiated the TRAINTODAY project, the goal of which is to determine whether it is better to train up-front in the classroom or just-in-time in the field. Since the application of distance learning is fundamental to this research, a first step was to understand the learning that it mediates. A review of the literature in distance learning, specifically as it applies to training, was required. In particular, an assessment of the experimental designs, reporting, and interpretability of the findings were needed as previous reviews have focused on whether there was "no significant difference" between distance learning and classroom comparison groups.

Procedure:

Searches on relevant research databases resulted in 2,000 entries, the large majority related to education. Papers presented at conferences over the past three years were reviewed, and the Internet was queried for studies with documented experimental designs. The selection process resulted in the codification of 43 research reports that were most relevant to the research.

Findings:

Generally speaking, the distance learning research literature focused on education rather than training, was largely anecdotal, and when effectiveness was examined, it was not supported by strong experimental or quasi-experimental design. The studies analyzed in this report, with a combined sample size of 5,438 students, painted a generally positive view of the effectiveness of distance learning for training applications. However, for an understanding of why distance learning might be effective, there were problems with reporting some key instructional components: 40% of the reports did not mention course conversion or redesign, 25% did not mention instructional techniques, and 50% of reports did not fully describe the method of communication (technology) employed. Video teletraining was the dominant technology reported. Comparison groups were available only one-third of the time. Based on the reported literature, when distance learning was shown to be effective, it was difficult to determine why.

Utilization of Findings:

These findings will influence the incorporation of stronger research designs into the TRAINTODAY project. It should serve as a reminder to the research community to be more thorough in reporting findings. There was negligible coverage of knowledge retention and comparisons between up-front or just-in-time training options, critical constructs for the TRAINTODAY project.

TRAINING THROUGH DISTANCE LEARNING: AN ASSESSMENT OF RESEARCH FINDINGS

CONTENTS

Page

INTRODUCTION 1

DISTANCE LEARNING TECHNOLOGIES 3

Types of Technology 3
Implementation Practices 5

TRENDS IN DISTANCE LEARNING 5

DL in Business and Industry 6
DL in the Military 8
DL in Academia 12

PREVIOUS REVIEWS OF DISTANCE LEARNING 13

FOCUS OF CURRENT ANALYSIS 16

Description of Empirical Findings 19
Summary of Reviewed Studies 34

CONCERNS IN EXPERIMENTAL DESIGN 35

Examples 38
Suggestions for Design 38
Related Issues 39

COST EFFECTIVENESS OF DISTANCE LEARNING 43

FUTURE WORK 45

Learning and Training Outcomes 45
Evaluation 45
The Future of DL in Academia and Industry 46

SUMMARY REMARKS 47

REFERENCES 49

LIST OF TABLES

Table 1. Summary of Delivery Methods of Distance Learning 4
2. Percent of Companies Using Selected Delivery Systems, 1994-1996 6
3. Distance Learning Statistics (Phillips, 1998) 8
4. Department of Defense VTT Networks (G.A. Redding, 1998, personal communication) 11
5. Classification of DL Articles, 1987-95 (Koble & Bunker, 1997) 14
6. Categories of DL Studies, 1990-1996 (from Howard, 1997) 16
7. Courses and Samples in the Florida Teletraining Project (Bramble & Martin, 1995). 20
8. Comparisons Between Live and DL Instruction (Bramble & Martin, 1995) 20
9. Analysis of Amount Learned versus Previous Course Experience in the First Iteration of the Risk Management Course (n=202) (Wisher & Curnow, 1998) 26
10. Comparison Mean Ratings for Navy Benchmark (Wetzel, et al., 1996) and ARNG study (Wisher and Curnow, 1998) 27
11. Seven Dimensions Underlying DL Student Satisfaction (Biner, et al., 1994) 30
12. Percentage of Resident Course Materials Converted to DL Format (Phelps, et al., 1991) 32
13. Estimated Time for Course Conversion (Phelps, et al., 1991) 32
14. Results of Audio Teletraining (from Wisher and Priest, 1998) 34
15. Assessment of Completeness of Information in Research Reports 35
16. Approximate Design Used by Researchers in the Reviewed Studies 36
17. Interactions That Can Occur in DL 41

LIST OF FIGURES

Figure 1. Technologies Used in Distance Learning (from Walsh et al., 1996) 14
2. Areas of Distance Learning Research 15
3. Sample Sizes of the DL Groups found in 31 Studies (rank ordered by size) 18
4. Sample Sizes of the Comparison Groups found in14 Studies (rank ordered by size) . 18

INTRODUCTION

The Army plans to convert over 500 courses to a distance learning format, delivering training to a soldier when needed. As described in the Total Army Distance Learning Plan, in the 21st Century, soldiers will attend streamlined resident courses, preparing themselves through diagnostic-driven, self-paced distance learning modules delivered at home station in unit learning centers, at the job site, or in their residence. In recent years, there has been an escalating interest on the part of academia, industry, as well as the military to shift from the traditional face-to-face classroom to a distance learning format. This shift has been driven by an interest in reducing training costs while increasing accessibility.

Much of the interest in distance learning relies on the "no significant difference" phenomenon, which argues that distance learning is as effective as classroom instruction. The present report offers a critical examination of the research literature on the effectiveness of distance learning, especially as it relates to training rather than education. This report is intended for training analysts, researchers, and others needing a more thorough understanding of that literature.

In a variety of forms, distance learning has been an alternative to the traditional classroom for over one hundred years. The term *distance learning*, also termed *distance education* (*Fernstudium* in German), and most recently *distributed learning*, was coined by Otto Peters and other practitioners at the University of Tübigen in the 1960s (Moore & Kearsley, 1996). Research on distance learning (DL) began appearing approximately fifty years ago, with monographs and articles on the topic becoming common in the 1960s (Holmberg, 1987). Several defining characteristic of DL are: teachers and learners separated physically while instruction occurs synchronically, the presence of noncontiguous communication between student and teacher (through electronic media or print), and the volitional control of learning by the student rather than the instructor (Keegan, 1986; Sherry, 1996).

One definition of DL, articulated by the Los Alamos National Laboratory, is the "structured learning that takes place without the physical presence of the instructor." This definition has been accepted by the U.S. Distance Learning Association and by military, government, education, and private sector activities concerned with the development and use of DL. With the recent emphasis on the application of electronic technology to DL, an extended definition has also been suggested:

> "Distance education is planned learning that normally occurs in a different place from teaching and as a result requires special techniques for course design, special instructional techniques, special methods of communication by electronic and other technology, as well as special organizational and administrative arrangements." (Moore & Kearsley, 1996, p. 2)

This report reviews the research on the effects of these techniques, particularly instructional techniques and methods of communication on learning. Other topics of interest include interactions between student and instructor, individual differences, and the cost-effectiveness of DL programs.

The available documentation on DL is vast and grows weekly. Several thousand journal articles, book chapters, research reports, and other forms of technical documentation have been published on the topic. Remarkably, a recent analysis by the Air Force indicated that there were over 1,000,000 DL hits from an Internet search (Vornbrock, 1998). In addition to the many Internet postings, there are several scholarly journals that focus specifically on DL. The key refereed research journals in the field are *The American Journal of Distance Education*, the *Journal of Distance Education*, *Research in Distance Education*, *Distance Education*, and *Open Learning*. Research articles also appear in numerous journals related to educational technology, instruction, education, and psychology.

This report offers a review of the literature that, while certainly not exhaustive, is representative of its methodologies and findings. Our goal is to form a perspective after reviewing studies concerning DL as applied to training. It should be noted that when summarizing the previous reviews and analyses of DL literature: (1) most research is anecdotal; (2) most focuses on education rather than training; (3) when effectiveness is examined it is usually not supported by a strong experimental or quasi-experimental design; (4) when effectiveness is measured comparative test results are reported approximately one-third of the time; and (5) when data are reported there are analytic problems and errors in reporting that are often overlooked by researchers. This review should both summarize what is known and serve as a framework for future research on distance learning.

Our focus will be on training rather than education. Education, by its nature, is open-ended whereas training is linked to organizational objectives and correcting deficiencies in the workforce (Kraiger & Jung, 1997). Although both encompass learning, our interest is in what DL can contribute to "a planned effort by a company to facilitate employee's learning of job-related competencies," as training is defined by Noe (1999, p.3). Unlike DL applications for education, which tend to orient learning to achievement on a written test, DL for training should involve "the systematic acquisition of skills, rules, concepts, or attitudes that result in improved performance in another environment" as identified by Goldstein (1993, p.3). There are gray areas within this distinction, such as the instruction that occurs in colleges and universities for technical, certificate and graduate-level courses within a particular career field. On a selective basis, such courses will be included in the review.

DISTANCE LEARNING TECHNOLOGIES

Although DL is often equated with technology, print in the form of correspondence study is still the most prevalent medium used in distance learning (Moore & Kearsley, 1996). Computer-based training is another popular medium. These two media will not be examined in this report unless they are applied in combination with other methods of instructional communication. Readers may refer to Hannafin, Hannafin, Hooper, Rieber & Kine (1996) for a review of computer-based training and Pittman (1990) for a review of the print medium. This report focuses on DL implementations that apply information technology to link audio, video, text, and graphic images between two or more sites for the purposes of training. Before reviewing the research findings, a brief survey of the growth of DL will establish the importance for such an examination of the literature.

Types of Technology

The majority of DL classes employ video teletraining (VTT) technologies. Interaction among the instructors and students is provided using two-way video with two-way audio (57% of classes) or one-way video with two-way audio (25%); furthermore, one-way prerecorded video, either alone or in combination with interactive video, is used in 52% of DL classes (National Center for Educational Statistics, 1997; Walsh, Gibson, Miller, & Hsieh, 1996). Most organizations offering DL use a combination of technologies. Video is used more often by

industry than academic or military organizations. Also, computer-based training is used least by academia, whereas industry uses this type of technology 85% of the time (Walsh et al., 1996).

Given the dominance of VTT, there are delivery options concerning analog versus digital transmission, compression of the digital signal, satellite versus terrestrial, in addition to implementation considerations. Terrestrial broadcast offers additional options for microwave, fiber optic, cable, or telephone transmission. Their advantages and disadvantages are described in Redding and Fletcher (1994). As the telecommunication industry advances, new technologies are being introduced while others become outmoded. This change offers new options for education and training delivery, such as audio and video streaming, computer telephony, viewer response keypads, and collaborative learning, all of which are being energetically pursued. At the same time, researchers in educational technology are designing innovative learning environments to take advantage of these emerging technologies (Duffy, 1997; Duffy, Lowyck, & Jonassen, 1993). Table 1 provides a description of current DL delivery methods.

Table 1.

Summary of Delivery Methods of Distance Learning

PRINT	Delivered through mail, facsimile, or downloaded from the Internet		
	Correspondence study	Training Manuals	Study Guides
AUDIO	Delivered over cassette players, personal computer, telephone, radio, or the Internet		
	Audio cassettes	Compact disc	Voice mail
	Audio conferencing	Radio broadcast	
	Audio teletraining	Streaming audio	
VIDEO	Delivered over videocassette players, personal computer, satellite, microwave, fiber optic, cable, telephone, or the Internet		
	One-way video, two-way audio	CD-ROM	Streaming video
	Two-way video, two-way audio	DVD	Videocassette
COMPUTER-MEDIATED CONFERENCING – Delivered through computer networks			
	Application sharing	Bulletin board	E-mail
	Audiographics	Chat Room	White Board
COMPUTER-BASED TRAINING – Stand-alone training applications; audio and video as above			
	Includes many computer peripherals, mass storage devices, printers, etc.		

Implementation Practices

Researchers address the relative effectiveness of DL for a variety of tasks, conditions, and standards, usually in comparison to a traditional classroom setting. Practitioners, of course, must determine the best course of action based on how-to publications, recommendations from experts, or a sensible analysis of their needs, organizational readiness, and training budgets. The basis of many practices derive from earlier research and evaluation findings that report the successes, and failures, of DL experiments, implementation efforts, and documented success stories.

Two recent publications that we recommend to the practitioners are Chute, Thompson and Hancock (1999) and Mantyla and Gividen (1997). These volumes describe how practitioners must first identify the performance shortfall they seek to remedy and then determine whether DL is an appropriate alternative. If DL is viable, will the organization accept the changes to training schedules and methods? How do you match technologies with training requirements? How can one document the return on investment? Will there be continued funding for a DL endeavor? These issues are addressed in the aforementioned books. One example from Chute et al. (1999) is the application of a decision-making tool for selecting a training technology: "IF the organization uses electronic mail, bulletin boards, and Internet-type applications AND your learning requires interaction between participants THEN consider a DL application which uses network based CBT, chat rooms or bulletin board technology" (Table 5-2, p. 76). In view of the rapid advancements in technology, practitioners must maintain a constant awareness of documented successes in the DL field. They must also beware of the limits of technology in workplace learning as suggested by others (e.g., Gordon, 1999; Morgan, Ponticell, & Gordon, 1998).

TRENDS IN DISTANCE LEARNING

Distance learning has grown enormously in recent years, and its prospects are tremendous as academia, industry, and the military increase their investments in its use. The confluence of advances in information technologies, a globally competitive economy, and the changing needs of the workplace require convenient access to resources for knowledge and skill acquisition. Advances in telecommunications and the desire of educational and training institutions to penetrate new market segments have rendered distance learning a common term.

Technology-based training systems have grown 40% annually in recent years, and analysts expect this trend to continue. "This market is really taking off, and tremendous attention is being paid by venture capitalists and other private investors," says the editor of an online training newsletter (*Investor's Business Daily*, December 2, 1998). An underlying force of this growth has been a technology push by the telecommunication suppliers, the education and training industry, and the military to make a determined commitment toward DL as a universal alternative to the traditional classroom.

There are many visible signs of this growth. In 1995, more students enrolled in DL courses than entered all the U.S. colleges and universities as freshmen. However, it is unclear if enrollment statistics between these groups are comparable since DL courses are often much shorter in duration and do not have enrollment figures as accurate as those of traditional colleges and universities. In a benchmarking forum conducted by the American Society for Training and Development, certain trends in DL were identified. These trends, displayed in Table 2, reflect the growing presence of the DL alternative.

Table 2.

Percent of Companies Using Selected Delivery Systems, 1994-1996

Year	Televised DL	Internet/network DL
1994	47%	12%
1995	64%	33%
1996	69%	3%

DL in Business and Industry

Training 50 million American workers is big business indeed, with over 60 billion dollars allocated to training in business and industry in 1998. There is direct evidence that investments in workplace learning improve a company's financial performance. For example, in a study that examined the relationship between training expenditures per employee and net sales and gross profit for 40 publicly traded companies, researchers found that companies with the larger per-employee training cost had a 57% higher net sales per employee and a 37% higher gross profit per-employee than those companies with a relatively smaller per-employee training cost (Bassi & McMurer, 1998). The same study also found that companies with leading-edge training

practices spent up to 6% of payroll on training and used high-end methods, such as the Internet, teleconferencing, and computer-based training to provide opportunities for workplace learning.

Given the relationship between training and profitability, industry is further motivated to increase the cost-effectiveness of training through the application of DL technologies. There is much evidence that this practice is increasing. For example, the Public Broadcast Service (PBS) has started "The Business Channel," offering an extensive array of business education and training using satellite and fiber optics networks with options for video-on-demand to the desktop. PBS is already the nation's single largest broker of college courseware in the nation, enrolling over 400,000 students in telecourses through the *Going the Distance* partnership with colleges and local stations. The National Technological University offers degree and non-degree programs in engineering and technical specialties through the redistribution of satellite signals from an originating university to multiple locations across the country. The consortium of 45 leading universities affiliated with the National Technological University are paid by the recipient organization, which is equipped with a satellite antenna, a classroom, and students in need of updating their technical skills while avoiding travel and time away from the workplace.

More than 150 corporations possess a business television capability, which is simply a private satellite television network capable of broadcasting live television programs to multiple locations. One example is the Ford Motor Corporation's *FORDSTAR* program. In this network a small aperture satellite antenna is installed at each Ford and Lincoln-Mercury dealership across North America for the purpose of providing training on product information, repair, sales, and service to over 190,000 dealership employees in North America. Using digital video technologies, this satellite-based communications network, when completed, will be the largest privately owned network in the world, offering the highest number of concurrent events on over 20 channels. Monthly schedules, patterned after a television guide, list the many course offerings. The results of this paradigm change in training have been impressive. The number of course enrollments has increased from just over 150,000 in 1994 to over 717,000 for the past year. Training is now convenient and effective. For example, the number of "false positive" returns of component parts sent back as faulty has decreased in direct relationship to those employees who participated in the maintenance training on a particular component (Conley, 1998).

On another front, Web-based training for the information technology workforce will grow from $92 million in 1996 to $1.7 billion in 2000, a growth of over 1,800%, with an emphasis on Intranet-based, asynchronous, self-paced instruction (*Web Week*, Sep. 8, 1997). Internet tools emerging in the training marketplace to simulate the traditional classroom and increase interactions between instructors-and-students as well as students-and-students include internet relay chat, multi-user dimensions, and multi-user simulation environments (Kouki & Wright, 1996). Table 3 summarizes some of the recent trends in distance learning marketplaces.

Table 3.

Distance Learning Statistics (Phillips, 1998)

- Number of students taking distance learning courses from higher-education institutions as of late 1997: 7,000,000
- Number of accredited degree and certificate distance learning programs: 1,200
- Number of accredited distance learning colleges: 900
- Percentage of corporate training delivered online in 1997: 16%
- Percentage of corporate training estimated to be delivered online in 2000: 28%

DL in the Military

Training in the military is substantial with a yearly training load (full-time equivalent students) of 165,000 (Military Manpower Training Report, 1998). Millions of dollars are spent on travel costs to transport soldiers, sailors, and airmen to centralized training facilities for periods ranging from several days to several months. The potential for cost savings through DL is clearly substantial. There is similar interest in military departments in Europe as well (Seidel & Chatelier, 1994).

All service branches are active in the implementation of DL technologies to replace traditional classrooms for both active and reserve components (Metzko, Redding, & Fletcher, 1996). The Army, for example, has recently approved a comprehensive plan for the Regular Army and the Reserve Component (comprising both the Army Reserve and Army National

Guard). This plan calls for the preparation of 745 classrooms at home and abroad as well as mobile and deployable classrooms for specialized training requirements. The plan calls for the conversion of 525 courses to a DL format. Fielding of the facilities is being timed to coincide with the availability of multimedia courseware and the infrastructure required to deliver VTT courses and other training products. The delivery system combines fiber optics, asynchronous transfer mode (ATM) switching, and some satellite transmissions to link classrooms, field training, armories, and reserve centers. Implementing the Army's DL system is planned to continue through 2010.

Of special note is the DL initiative of the Army National Guard. The Guard maintains nearly 3,200 armories in 54 states and territories, all of which could be used as DL training centers. Properly configured and managed, such an arrangement can overcome the disadvantages of geographical dispersion of members and the inconveniences of an intermittent training schedule. An additional feature of the Army Guard's network is shared usage, whereby other government, educational, and civic organizations, as well as private businesses, can use the network and DL classrooms on a fee basis when it is available (Byrne, 1998). Since Guardsmen generally use the armories only a few days each month, they can also serve many non-defense educational and training purposes.

The Navy does not have a formal DL plan per se. Rather, it is integrated into an overall plan for training technology which encompasses both active duty and reserve sailors. Examples of DL in the Navy include an interactive VTT network that is used for both DL and teleconferencing. The system uses satellites to broadcast to ships at sea and telecommunication lines to deliver courses on shore. The network consists of 19 sites in major fleet concentration areas and 25 networked classrooms. It is available 24 hours per day and on weekends to serve the training needs of the Naval Reserve Force. In 1997, the Navy offered 52 courses of instruction through its network. All students receive the same certificates of completion as those who attend traditional classes. The Naval Postgraduate School has initiated a DL program for its students on the network. Navy medical centers also make use of this system, both to conduct courses and to practice telemedicine. Marines at Navy locations also take courses on the network.

The Marine Corps is planning a wide reaching and interconnected Marine Corps Learning Network (MarineNet) to support individual learning. The concept is dependent on

previously planned upgrades to the their telecommunications and network infrastructure as well as the conversion of traditional courses to electronic media over the next several years. The initiative includes growing use of the Internet for student information, registration, and administration. The Marine Corps is converting their skills training courses to a DL format, moving toward courses written for the Internet and Intranet delivery. The expectation is that every military occupational skill in the Marine Corps will have a DL module. Plans also call for a Training and Education Point of Presence to be installed at each Marine Corps base and station. Every networked workstation will have access to digital training materials. The Marine Corps is also mindful that approximately 60% of its training is provided by the other services, and their DL network must be able to access those training resources.

The Air Force is planning the development of a world-class DL education and training system and to that end established the Air Force Institute for Distance Learning in 1998. Currently, tens of thousands of Air Force students around the globe take courses delivered through a variety of DL formats. These numbers are anticipated to grow in the future, as investments are made in organization, facilities, course conversions, telecommunications infrastructure, and instruction for faculty and courseware developers. As a result of trends identified in the Air Force 2025 Project, the Air Force expects that education and training programs may be adjusted to meet the individual needs of students in an anytime-anywhere environment.

The Air Force Institute of Technology provides graduate, professional, and specialized education to members of the Air Force and has a growing distance learning presence. This institute is responsible for everything but content, dealing with course conversion, administration, and broadcasts of distance learning events (Westfall, 1998). Also, the Air Force Reserve Component is to produce and deliver distributed learning through many delivery systems, including the Internet.

The Services operate eight separately managed VTT networks. Each network can send and receive courses using internal network resources, and can model commercial broadcasting with one-way video or video telecommunication with two-way video. Both types use two-way audio to deliver instruction. Table 4 identifies the eight networks used by the Services.

Table 4.

Department of Defense VTT Networks (G.A. Redding, 1998, personal communication)

Network	Video Capability	Audio Capability
Chief of Naval Education and Training Electronic Schoolhouse Network	Two-way	Two-way
Navy Medical Education and Training Network	One-way & two-way	Two-way
Marine Corps Satellite Education Network	Two-way	Two-way
Satellite Education Network -- Army	One-way	Two-way
Training Network -- Army	Two-way	Two-way
Air Technology Network -- Air Force	One-way	Two-way
Air Force Reserve Network	Two-way	Two-way
Warrior Network—Air National Guard	One-way	Two-way

The military has conducted extensive research and analyses on the effectiveness of distance learning (cf. Barry & Runyan, 1995; Howard, 1997). As the implementation of DL continues, research will likely continue on topics such as training on demand, digital skills, and collaborative team training. In higher education, gaps in the research have been identified in areas such as learning styles, drop-out rates, and interaction of multiple technologies (The Institute for Higher Education Policy, 1999). There will be a continuing interest in analyses to determine return on investment, to provide baseline measures for continued improvement of training products and processes, and to prepare for new training technologies emerging from academic, industrial, and military laboratories.

Distributed Learning

The Advanced Distributed Learning (ADL) initiative is a Department of Defense undertaking whose strategy is to promote widespread collaboration, exploit network-based technologies, lower development costs, and develop next generation learning technologies by creating reusable content at a lower cost using object-based tools. The Advanced Distributed Learning initiative will employ an Instructional Management System (IMS) to tag and manage the learning objects produced as a result of the initiative. For example, an object representing an animation of a moving truck created for an Army training program could be clipped from the

IMS and pasted into an Air Force training program or even a commercial training program. One of the goals is to develop an automated system that will perform information management functions by keying on the IMS indexing feature. The ADL initiative will provide a unified "system of systems" for use by all Department of Defense personnel (Office of the Undersecretary of Defense for Personnel and Readiness, 1999).

DL in Academia

In 1995, there were 25,730 DL courses offered by institutions of higher education in the United States with an estimated 690 degree programs and 170 certificates offered exclusively at a distance (National Center for Education Statistics, 1997). From 1996 to 1998, distance education was projected to grow dramatically in a variety of remote sites: branch campuses, student's homes, work sites, libraries, community-based organizations, and correctional institutions. Approximately 75% of the institutions currently offering distance education courses have plans to begin or increase their use of two-way interactive video and two-way online interactions. The 1997 Campus Computing Project survey shows that nearly 33% of courses offered at the 605 institutions polled use electronic mail, up 25% from 1996. The same survey indicated that the percentage of courses at private universities using e-mail is 60%, and nearly half of public university courses use the electronic-mail medium (*Chronicle of Higher Education*, Oct. 17, 1997).

Unlike industry and the military that focus on DL as a cost-effective alternative to the traditional classroom, academia must focus on DL as providing a value-added commodity. Both industry and the military can justify DL costs as a means to avoid travel costs and the productivity loss of workers in transit to training. Here, the claim that training is "as good as" the traditional classroom is acceptable. Since the students are already present at the traditional university, justifying costs for DL cannot stem from a reduction in travel costs or productivity but rather focus on improvements in learning in which education and training is "better than" the classroom. Examples of "better than" include new methods of instruction, such as collaboration with remote sites and asynchronous conferencing. Of course, in some cases DL can offer greater access for students at satellite campuses, in which case the learning outcomes do not necessarily need to be better than the classroom. This situation is changing as colleges and universities expand their markets and compete for students. In higher education, shortcomings in the

research on the educational effectiveness in DL have been recognized; gaps in the research have been identified in areas such as learning styles, drop-out rates, and the impact of interaction of multiple technologies (The Institute for Higher Education Policy, 1999).

PREVIOUS REVIEWS OF DISTANCE LEARNING

The published literature on DL is overwhelmingly anecdotal. Evaluations are usually informal and conducted by users rather than independent sources. Large-scale evaluations have tended to focus on issues such as usability, learner preferences, and equipment quality rather than learner outcome (Council of Chief State School Officers, 1995). In the voluminous literature, comparatively little research has examined teaching effectiveness in DL (Webster & Hackley, 1997) and most of this has been oriented towards education rather than training. For example, of the 241 articles cited by Russell (1998) demonstrating a "no significant difference" effect between traditional classroom instruction and instruction through distance learning, our analysis indicates that only 13% focus on traditional training courses; much of this work was conducted in the 1950s and early 1960s with print and instructional television. It should be noted that failing to find a significant difference between DL and traditional classrooms does not, from a statistical perspective, mean that the two are the same. Failing to reject the null hypothesis (in this case that DL and traditional classrooms produce the same outcomes) should not be interpreted as evidence that the null hypothesis is true. Instead it is appropriate to suspend judgement due to a lack of sufficient evidence (Dayton, 1970).

Several researchers have reviewed earlier findings and examined research trends on the topic. Scriven (1991) reviewed 109 articles published in the *Distance Education* journal during its first ten years and classified them by topic. The three largest topics were (a) students and their characteristics (23 articles), (b) courses and instructional programs (20 articles), and (c) telecommunications and media (13 articles). Scriven reported no significant trends in these articles other than work on course attrition (i.e., dropouts) and features of course design. More recently, Koble and Bunker (1997) examined the abstracts of 129 major articles from *The American Journal of Distance Education* published between 1987 and 1995, and classified them according to categories offered by the International Centre for Distance Learning. The results of this classification are presented in Table 5. Within the media and delivery systems topic of the Koble and Bunker (1997) classification, nine articles concerned video delivery, nine centered on

computer delivery, five involved audioconferencing, and one dealt with correspondence instruction. The others were various combinations of media.

Table 5.

Classification of DL Articles, 1987-95 (Koble & Bunker, 1997)

Topic	Number of Articles	Percentage
Theory, policy, and development	33	26%
Media and delivery systems (Effectiveness/evaluation methods)	27	21%
Institution, staff, and management	20	16%
Student psychology, motivation and characteristics	19	15%
Faculty participation and instructional process	14	11%
Course design and curriculum development	13	10%
Student administration and support	3	2%

A review of the characteristics of DL in different settings demonstrates that many studies are not supported by an adequate experimental design and do not offer objective measurement of variables (Walsh et al., 1996). Based on a survey of 129 organizations involved with DL, Walsh et al. (1996) found that much of DL is simply VTT with an instructor presenting material to students at remote sites. Figure 1 below denotes the percentage of the 129 organizations reporting the use of a particular technology.

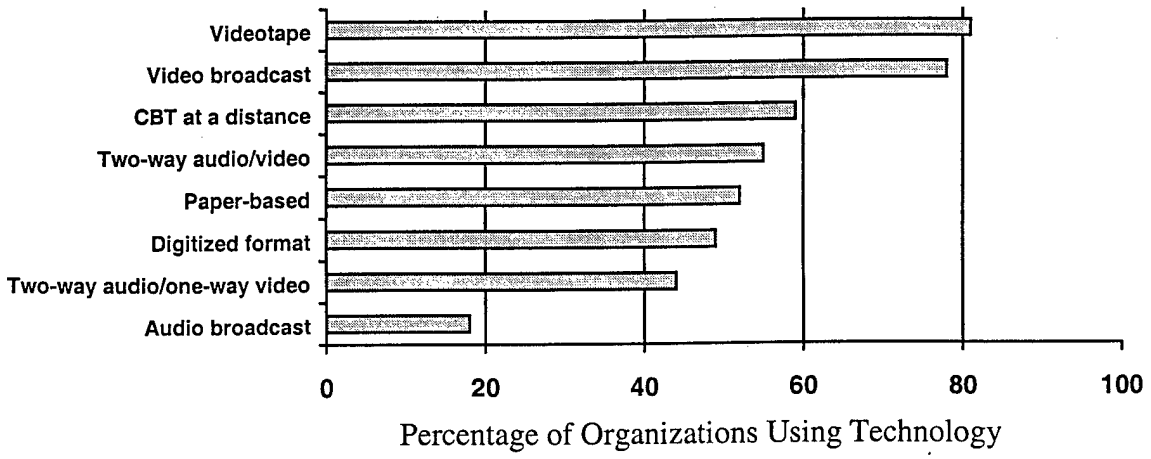

Figure 1. Technologies Used in Distance Learning (from Walsh et al., 1996)

Another interesting analysis from the Walsh study was the type of research conducted. Figure 2 charts these data for five research categories from the 125 organizations that responded to this question. The most common area of research was on instructional effectiveness, which was further categorized as student opinion questionnaire (59%), instructor opinion questionnaire (39%), comparative test results (36%), retention data (16%), and transfer data (16%).

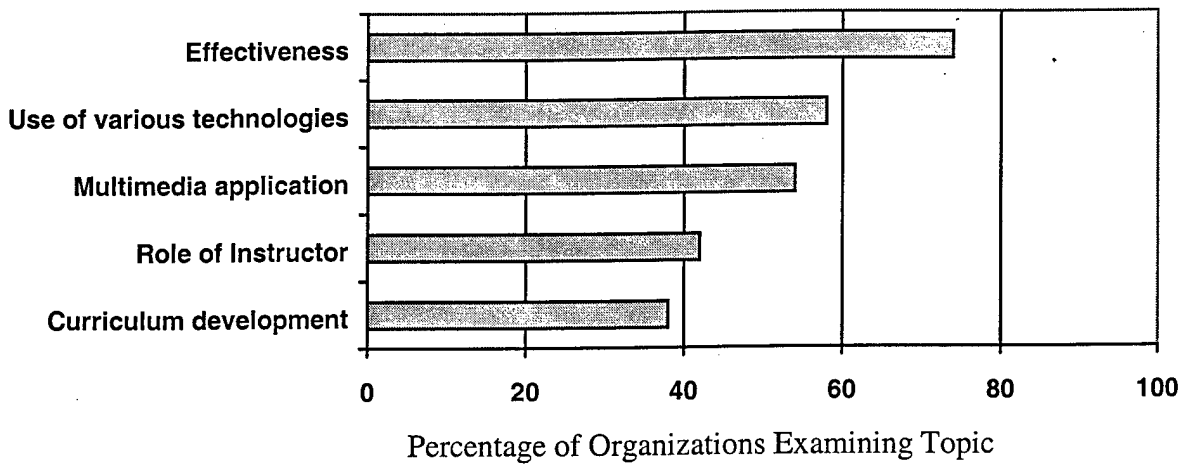

Figure 2. Areas of Distance Learning Research

In an effort to develop a practical user's reference, Howard (1997) consolidated available empirical evidence on adult education and DL from 300 reports published between 1990 and 1996. Of these 300 documents, only 106 (35%) were considered appropriate based on source, subject matter, and evaluation methods. These articles and books were further divided into ten categories based on the interests of the study's sponsor (the Army). Some documents accounted for in Table 6 were included in more than one category.

Table 6.

Categories of DL Studies, 1990-1996 (from Howard, 1997)

Topic	Number
Evaluation of DL	57
VTT, video tapes, interactive videodisc	35
Computer-based training, computer-mediated conferencing	20
Cost effectiveness and systems costs	18
Student interaction with instructors, students, and technology	16
Descriptions of specific DL programs	11
Guidelines for planning and implementing DL	9
Professional Education	7
Reviews of DL literature	7
Miscellaneous	10

FOCUS OF CURRENT ANALYSIS

Research in DL has been exhaustively documented and reviewed, but there has not been a systematic examination of research methodologies, experimental designs, variables, comparison groups, sample sizes, and other research factors that might serve as the scientific basis for establishing DL as an alternative to the classroom. This report examines these issues. Suen and Stevens (1993) reviewed the common analytic problems and errors often overlooked by researchers in DL. These problems and errors were significance testing, assessment issues (i.e., information about reliability and validity), statistics (e.g., error rates, practical significance), and reporting practices (e.g., demographics, non-significant findings, degrees of freedom).

For our analysis of research on training using a DL format, the broad ranges of studies reported in the literature had to be reduced to a manageable size. We first performed searches of a number of relevant databases (resulting in over 2,000 entries) and then searched the World Wide Web for relevant facts and figures. We reviewed the 1996, 1997, and 1998 Proceedings of the Annual Conference on Distance Teaching and Learning held in Madison, Wisconsin, for recent contributions from this significant annual meeting. Our analysis of the papers presented at the Madison conference indicated that 8% (16 out of 200) concerned empirical studies of DL, and even fewer were related to training. Cross-references from other review articles and some key books on distance learning were also examined for relevant sources. Our goal was to

identify a representative sample of evidence that was restricted to training but focused on two key ingredients of the Moore and Kearsley (1996) definition of DL -- instructional techniques and methods of communication.

Since our focus was on training, we restricted subject areas from academia to methodological and technical courses, graduate-level courses, and continuing education programs rather than introductory or lower-level undergraduate courses. Studies conducted on K-12 populations were excluded unless they clearly contained training objectives, such as vocational instruction or foreign language training at the high school level. Research on DL in the military and industry was acceptable unless it was oriented to educational programs. Literature reviews and planning reports discussing research and training issues were also included. Our selection process resulted in the codification of 43 research reports, seven of which were reviews of research literature and three of which were oriented to planning for implementation of training programs that included research and evaluation methods. Of the remaining 33 reports, the delivery methods are described below, with some having a combination of two media:

- 27 (82%) included VTT as a communication medium
  - 13 one-way video/two-way audio
  - 6 two-way video/two-way audio
  - 2 videotape exclusively
  - 6 were not clearly identified
- 3 (9%) were audio only (including audiographics)
- 3 (9%) included computer-mediated instruction
- 6 (18%) were videotape (in combination with another DL medium)
- 4 (12%) included print (in combination with another DL medium)
- 1 (3%) included CBT (in combination with another DL medium)

Of the 33 reports, 31 reported learning outcome data, 14 had a comparison group (trainees received the information live, rather than at a distance). The median size of the DL group represented in a single report was n=106 (range 14 to 1,044 students) and the median size of the comparison group was n=84 (range 18 to 401 students). It should be noted that some reports included several iterations of the same course or had several classes reported as a single investigation. When this was taken into account, the average "class size" for a separate DL course was approximately 36 and the average size of a comparison class was approximately 22.

Altogether, the database represented 5,438 students being trained through DL with 1,806 comparison students, a ratio of one comparison student for every three DL students. The rank order distribution of sample sizes for the DL and comparison groups are charted in Figures 3 and 4, respectively.

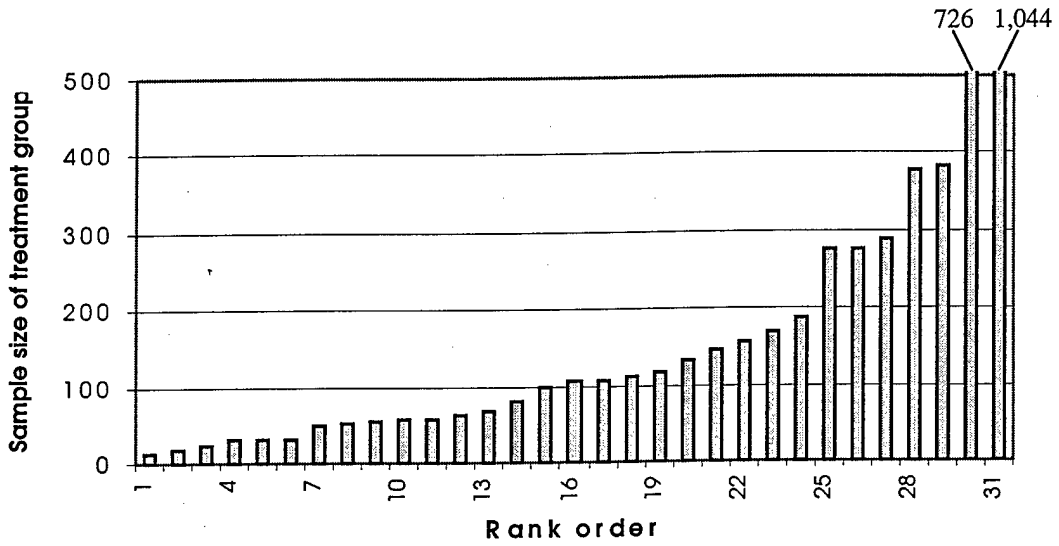

Figure 3. Sample Sizes of the DL Groups found in 31 Studies (rank ordered by size)

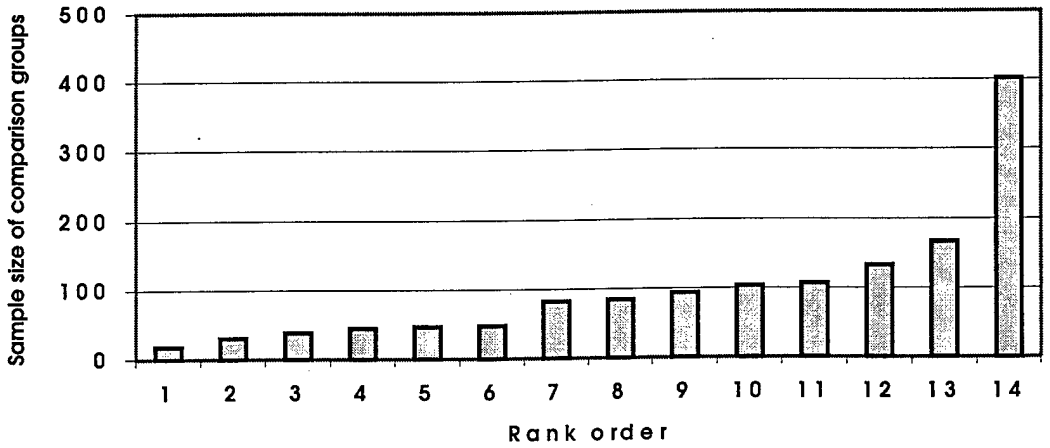

Figure 4. Sample Sizes of the Comparison Groups found in14 Studies (rank ordered by size)

Description of Empirical Findings

VTT is an educational application derived from teleconferencing which allows the delivery of training occurring in a classroom to remote sites (Wetzel, Radtke, & Stern, 1994). The essential components of the originating classroom are the instructor, the visual images being displayed, and audio. Students are sometimes present at the origination site; a two-way video connection which allows instructors to see students is possible. Typically, there is an audio return from the remote sites, usually through a telephone connection. Given the array of possible implementations, the general conclusion is that students at remote sites exhibit either no difference or only a slight decrement in learning when compared to those at the live site or to a comparison group in a traditional classroom (Chute, Balthazar, & Poston, 1988; U.S. Office of Technology Assessment, 1989). The category of VTT provided the overwhelming number of research reports for our analysis. The descriptions of the reports include reported information on course subject and length, method of communication, course design or conversion to DL from a traditional format, the DL and comparison samples, the dependent variables, and the results.

Military Teletraining

Bramble and Martin (1995) reported on the Florida Teletraining Project, which tested the feasibility of using community colleges to deliver training courses to military reservists with the use of two-way video/two-way audio technology. The project developed, delivered, and evaluated five courses for personnel at five remote sites in three states. The media employed were compressed video (256 Kbps) transmitted by satellite, a document camera capable of transmitting images, and printed student study guides.

Each of the five courses was converted from previously developed courses. The reconfiguration to a DL format was accomplished within a six-month period (no further details were provided). A common methodology in the course design was the use of word pictures, which provided a graphic depiction of key concepts in full form during the video presentation, but which omitted the key words in the student guides (Cyrs & Smith, 1997). The courses, course lengths, and sample sizes for the study are described in Table 7.

Table 7.

Courses and Samples in the Florida Teletraining Project (Bramble & Martin, 1995)

Course	Course Length	Sample
Unit Administrative Specialist	73 hr.	33
Unit Supply Specialist	96 hr.	40
Basic Military Police	66 hr.	26
Handling Hazardous Waste	6 hr.	116
Total Quality Leadership	6 hr.	60
Total sample		275

Dependent variables were standard, criterion-based proficiency and achievement tests for the three longer courses and 20-item achievement tests for the two short courses. Pre- and post-tests were given for every course except total quality leadership. Overall student ratings of the course components were collected along with students perceptions of the course. The results are displayed in Table 8. The technology was found to be reliable and the performance tests indicated solid learning gains. No comparison group was included.

Table 8.

Comparisons between Live and DL Instruction (Bramble & Martin, 1995)

		Performance		Reaction
Course	Measure	% pre-post gain	t-value	"Effective as live instruction?" % yes
Admin Spec.	Timed Typing-wpm	58.3%	11.4*	55%
	Type Memo-errors	-75.1%	-7.0*	--
Supply Spec.	Achievement test	26.8%	8.6*	75%
Milt. Police	Achievement test	28.9%	13.6*	76%
Haz. Waste	Achievement test	64.1%	21.5*	84%
TQL	Achievement test	N/A		81%

*p <.001, one-tailed test

Research in the Navy

Wetzel and colleagues (Simpson, Wetzel, & Pugh, 1995; Wetzel, 1996; Wetzel, Radtke, Parchman, & Seymour, 1996a; Wetzel, Pugh, Van Matre, & Parchman, 1996b) evaluated VTT courses, with two-way audio, delivered by the Chief of Naval Education and Training. These courses in quality assurance, basic leadership, and fiber optic cable repair were delivered to Navy personnel. In each of these studies, no differences in performance were found between instruction delivered in a traditional classroom format and that delivered via VTT to either local or remote sites.

Basic leadership training. Simpson et al. (1995) described an existing course in basic leadership that was converted to a VTT format. Four instructors taught 105 Navy officers located at local (n=36), remote (n=22) and traditional classroom (n=47) sites using a variety of methods including lecture, discussion, experiential learning, and team-building exercises. Although there were small but non-systematic differences between the DL remote, DL local, and traditional classrooms in terms of student perceptions, participation, and the observations of subject matter experts, there were no significant differences between locations in student knowledge and perceptions of training and learning quality. On average, students' performance on a 25-item multiple-choice test increased 22% between pre- and post-test administrations. All three groups – comparison, the DL local, and the DL remote – had approximately equivalent increases. This study was notable in its use of multiple measures of key criteria. For example, student participation and interactions were lower in the two DL groups based on an objective count of questions and comments by observers, subject matter expert's observations, and self-report by students.

Fiber optic cable repair training. Wetzel et al. (1996), examined 50 students who were instructed over five days with a structured format of lecture, computer-based training, demonstrations, laboratories, homework reviews, and question and answer periods. Students were approximately, but not randomly, divided among two DL groups (DL local and DL remote), and a comparison (non-DL) group. The scores on the course final exam were slightly higher in the comparison group (86% correct) than in the DL local (85%) and DL remote (80%) groups, but this difference was not statistically significant. Although it took students longer at the remote site to complete their lab assignments, there were no significant differences between

the groups in terms of procedural errors, observer ratings of safety, quality of work, or objective errors.

Quality assurance training. Similarly, Wetzel et al. (1996b) found no mean differences in final examination scores among 233 students taking a course in quality assurance at a local (94% correct), remote (92%), and comparison site (94%). A second measure of performance was administered to students in the local and remote DL groups. Average scores on this end-of-course 10-item quiz on computer procedures were nearly identical (46% vs. 47% correct).

Celestial navigation. Wetzel (1996) performed the evaluation of a refresher course in celestial navigation. Students (n=279) across two DL groups (remote and local) and a comparison group were compared on performance, reaction measures, and amount of interaction as determined by an observer. There were no significant differences among the DL groups on students' homework scores, but students in the remote group scored slightly, but statistically, lower on their final examinations than students in the local group. When inequities in seniority status were controlled in this data, students in the remote condition still scored 4% lower than those in the local site. The use of picture-in-picture technology received overwhelmingly positive responses from students at the remote site, but students at the local site were ambivalent about this technology.

One-way Video / Two-way Audio Media

Although the courses using VTT to this point involved two-way video and two-way audio, Crawford and Suchan (1996) argued that one-way video and two-way audio systems are far less costly and just as rich a communication medium when learning outcomes require only verbal interaction between students and instructors. They make a convincing argument that the choice of media used should be determined based on the necessary learning outcomes and instructional technique. Of course, the availability of the necessary media might be a deciding factor.

New product training. Souder (1993) delivered the same semester-long course on managing new product innovations to 24 students via one-way video/two-way audio technology, 13 students live in the broadcast studio (who were able to interact with the DL group) and 20 students at a separate time in a traditional classroom. No information was provided on course design or conversion. All students took the same essay examination and completed a research

term paper. Students in the DL group scored significantly higher, on average (95% correct), than students in the comparison broadcast studio group (92%) but not higher than those in the comparison traditional group (94%). Students in the DL group also received significantly higher grades on their case study analyses (95%) than students in the broadcast studio group (85%). There was no difference in performance on the research term papers among the three groups. As the author notes, however, the three groups of students differed dramatically in terms of age, grade point average, and industrial experience, with those in the DL group significantly higher on all three factors.

Air traffic quality assurance training. Lennon and Payne (1997) examined the differences in student reaction and learning outcomes between DL (one-way video/two-way audio) and comparison non-DL groups of Air Traffic Quality Assurance Specialists of the Federal Aviation Administration. The 7 ½-day course ("Quality Assurance Program Administration") was delivered on two occasions by four instructors to a total of 31 employees in the non-DL group and delivered by a trained instructor to 18 employees at four sites (DL group). There were no significant differences on any of the 12 reaction measures, which were rated on a 5-point scale and included pace of training, relevance to job, effectiveness of instructors, and overall quality between the two groups. In addition, there were no differences between the groups on either the pre-test or post-test knowledge measures that consisted of 50-item multiple choice open book tests.

Health care providers. An overlooked population of individuals in distance education is the elderly. Coogle, Osgood, Parham, Wood, and Churcher (1996) addressed this gap by evaluating a teleconference on the topic of geriatric alcoholism which targeted, among others, older adults and their family caregivers. This two-hour program was delivered to 134 participants via one-way video/two-way audio technology. It consisted of a panel of four experts who presented information on topics such as signs and symptoms of alcoholism and differences between younger and older alcoholics. In addition, the panel used live dramatization, case studies, and answered questions phoned in by participants.

The same 23 questions were given both as a pre-test and a post-test on the course concepts. As a whole, the participants' knowledge significantly increased between the two administrations (pre-test: 67% correct; post-test: 82% correct). This pattern of increase was similar for both the elderly residents (n=9) and the service providers (n=87). The researchers concluded that the

interactive teleconference was an effective vehicle for delivering education to older adults. However, without the benefit of a comparison group, it is difficult to determine if the gains in knowledge were due to other factors, such as simple memory effects or whether the same gains could have been achieved by having participants read a pamphlet with the necessary information rather than delivering the information via distance education technology.

Air traffic control and knowledge retention. In a study that focused on the effects of knowledge decay over extended periods during a distance learning course, Wisher, Seidel, Priest, Knott, and Curnow (1997) examined air-traffic-control operators distributed to Army National Guard soldiers (n=32) at eight remote sites over an 11 month period. The media employed was one-way video/two-way audio supplemented with study guides and the training manuals used in the resident course. The course had six phases: the first four, which were taught through DL, were knowledge-oriented on topics such as aviation weather, or rules and principles for radar and tower operations; the final two phases were taught in residence at Fort Rucker, Alabama, and were hands-on, skill-based training on radar and tower operations.

The course was converted from the resident version, primarily by the instructor, for the DL course (no details on time or costs were provided). The soldiers in the comparison group (n=45) attended all six phases of the course for 11 weeks at Fort Rucker. The dependent variables were a controlled exam on fundamental control tower procedures administered by the Federal Aviation Agency, a knowledge retention test, achievement test scores, performance scores, and completion rates. The knowledge retention test concerned topics trained in the first phase. Due to course schedules, it was administered 20 weeks later for the DL group and 10 weeks later for the comparison group. The achievement test scores measured the four knowledge phases; performance scores measured the two skill-based phases of training.

The results indicated that the DL group performed as well as, but not better than, the comparison group on the knowledge phases of the training. For knowledge retention, the DL group dropped 14% over 20 weeks in contrast to a 15% drop in the comparison group after 10 weeks. This drop was similar to that found by Semb and Ellis (1994) who determined that in 23 studies of knowledge retention over periods of 20 weeks or less, the relative loss of knowledge was 13.7%. On the basis of Wisher et al. (1997), training through distance learning was retained as well as conventional classroom instruction. The major difference was in performance in the two skill phases where the DL group had a success rate of 58% on the tower laboratory

compared to a success rate of 90% for the comparison (non-DL) group. For the radar laboratory, the DL group had only a 14% success rate compared to an 85% success rate for the comparison group. The authors believed that while the facts and declarative knowledge were well retained, the retention interval of three months between learning and applying the rules and principles was too lengthy. This did not allow an immediate transition to applying these rules and principles in the laboratory, where speed and accuracy of responses were critical. The comparison group was able to immediately apply that knowledge, as their phases were contiguous.

Engineering training off-campus. In a study on engineering training at the graduate level, Stone (1988) examined the characteristics of students enrolled in off-campus degree and continuing education programs to on-campus students. The semester long courses were in the engineering field. Data were collected over a five-year period. The DL group received either a one-way video/two-way audio satellite transmission or a videotaped version of the lectures; the comparison group received the same lectures in the classroom (classrooms were equipped with satellite transmission and video recording capabilities).

The DL sample contained off-campus students (n=726) and the comparison group was composed of students (n=302) attending the lectures face-to-face with the instructors. The dependent variable was grade point average (GPA). The results of an analysis of variance indicated that the DL group for the degree program had achieved a significantly higher GPA than the on-campus comparison group (3.44 versus 3.25); the continuing education students had a GPA of 3.21. This did not have a direct comparison to an on-campus program but, in view of the sample, would likely equate to the on-campus degree group. These data clearly support the supposition that VTT and videotape (in combination with the printed text) were equally effective in training technical knowledge and skills.

VTT evaluation techniques. In an analysis of one-way video/two-way audio delivered by satellite, Wisher and Curnow (1998) sought to develop a single-page evaluation instrument for short-term training events, defined as those occurring within a single day. Eight separate training events were analyzed. Six were oriented to military training topics, such as risk management and airborne call for fire, and two were oriented to more general civilian topics.

The courses did not have built-in performance evaluation measures such as an end-of-course exam or a proficiency test. As a surrogate learning outcome measure, the researchers applied a two-part self assessment scale that asked first whether or not the student had

participated in a previous course on the topic. It then asked "compared to what you already knew about topics related to (today's training topic), how much more did you learn from this training event" (Wisher & Curnow, 1998, p. 19). Previous research has demonstrated the utility of such assessments for military personnel, where training is conducted continually and performance is frequently assessed on a dichotomous GO or NO GO basis with prompt feedback. The courses were either originally developed for the broadcasts or were largely intact from existing courses with minimal conversion required. The DL sample was comprised of members of the Army National Guard (n=1,044). No comparison group was included. The dependent variables were the self-assessed prior knowledge and learning described above. There were also a series of nine questions related to the quality of the technology and perceptions of the instructor (e.g., quality of video, responsiveness to questions).

The results of the surrogate learning outcome measure are presented in Table 9 for the first iteration of a one-day risk management course. Note that the simple variable of having had or not had a previous course on the training topic clearly distinguished the two groups, with nearly twice as many who had no previous course reporting that they learned a lot from the training. This pattern of greater learning held in each of the six military training events and was significantly different as tested by an analysis of variance ($p < .001$). This supports the face validity of the measure. Within the three iterations of the risk management course, an ANOVA revealed no significant differences among the three events, which lends support to the reliability of the measurement technique.

Table 9.

Analysis of Amount Learned versus Previous Course Experience in the First Iteration of the Risk Management Course (n=202) (Wisher & Curnow, 1998)

	No Previous Course	Previous Course
Learned "a little" (1 or 2)	6%	22%
Learned "some" (3)	32%	46%
Learned "a lot" (4 or 5)	64%	32%

The results of the technology and instruction ratings are displayed in Table 10. As a comparative benchmark, the technology ratings described in Wetzel, et al. (1996) which has substantially similar questions and used the same scale are displayed.

Table 10.

Comparison Mean Ratings for Navy Benchmark (Wetzel, et al., 1996) and ARNG study (Wisher & Curnow, 1998)

Question	Navy Benchmark	Army Events		
		M	SD	n
Location of video screen	4.6	4.4	.81	1031
Quality of audio	4.1	3.8	1.21	1023
Quality of video	4.5	4.2	.96	1025
Instructor effectiveness	---	3.9	.91	960
Opportunity to ask questions	---	3.7	1.22	903
Responsiveness to student questions	4.5	3.9	1.00	849
Relevance of course to guard duties	4.3	4.1	.96	938
Overall learning environment	---	4.0	.99	1005
Overall effectiveness of instruction	---	3.8	.98	1000

Military command training. In a study by Keene and Cary (1990), the second phase of a course entitled Command and General Staff Officers' Course was offered through one-way video/two-way audio broadcast. A total of 145 Army reserve officers (n= 145) participated in the 69-hour course over a two week period. The DL instruction consisted of 41 of the 69 class hours (59%), where 21 hours were dedicated to lecture and discussion and 20 were used for practical exercises. The course design was modified from the traditional counterpart differing only in the video broadcast method of instruction. No additional details were provided.

This study included two DL groups (n = 36 and n = 26) and one comparison (non-DL) group (n = 38). The dependent variables were a pre-test and post-test of basic skills. The pre-test consisted of multiple choice items from a comprehensive skills exam, and the post-test included measures of recognition and recall learning. All students were taking the class for professional development and were similar on all demographic variables.

The measures of learning showed a difference in pre-test scores between the DL and comparison groups. A multivariate analysis of variance was used to compare pre-test to post-test scores. Taking the original differences into consideration, the DL group received significantly higher scores for three of the four measures.

Telecourse evaluation questionnaire. Bink, Biner, Huffman, Geer and Dean (1995) conducted a study on students taking college-level continuing education courses delivered through one-way video and two-way audio. Eighteen different courses of unspecified content were offered at 68 off-site locations throughout Indiana. A total of n = 106 students were included in the DL group. There was no information on course development or whether they were converted from previously existing courses.

The dependent variables include attitudinal and course-related items as well as a traditional predictor item (prior GPA). The Telecourse Evaluation Questionnaire was used to assess students' satisfaction on a 5-point Likert scale. Several independent variables, such as students' year in college, prior experience with telecourses and current course load ratings were considered. Additional demographic information was considered as well.

Final course grade was significantly correlated with prior GPA, ratings of satisfaction, and number of years in college. Using a multiple regression analysis, the authors found that prior GPA was a significant predicting variable for final course grade. Student ratings of promptness and number of years in college accounted for variance in final course grade that was unexplained by prior GPA. Demographic variables were not associated with final course grade in either analysis. Interestingly, ratings of satisfaction were significantly correlated with learning outcome, but much less than prior GPA.

Mathematics training. Larson and Bruning (1996) reported a study on a pre-college mathematics course that was equivalent to a pre-calculus course but was designed for those students who would not be taking calculus. The course was offered for a total of 33 weeks and consisted of classes 30 minutes in length with meetings three times a week. Through the use of one-way video/two-way audio, 91 lessons were offered via satellite. The remaining 66 lessons were supported by lesson guides (which included but were not limited to activities, assignments, teaching aids, etc.). Twenty-one DL sites were included in the analysis with a total sample of n=102 students. The comparison sample consisted of 102 students enrolled in a traditional pre-calculus course. The DL course was created specifically for the purpose of teaching students

who were considering furthering their education beyond high school but did not plan to take calculus courses. This DL course used textbooks, curriculum guides, and satellite broadcast videos in accordance with the multimedia recommendations by Pelton (1991).

An analysis of qualitative student perceptions of the DL format, curriculum, instruction, and students' disposition found that although most students reported enjoying the DL course, the majority of them would have preferred the traditional format. In addition, the comparison group performed significantly better than the DL group on both the pre-test and post-test of the placement test. This is not surprising since the classes focused on different types of students. Also of interest is that the percentage of students in the DL group at or above the appropriate level increased from the beginning of the DL course (from 51% to 65%) whereas the percentage of students in the traditional course at or above the appropriate level decreased (from 90% to 77%). The satellite course resulted in more correct placement of students in a mathematics course than did the non-DL course.

Information systems training. In a study that explored the application of a distributed group support system in the delivery of distance education, Fellers and Moon (1994) examined an upper-level undergraduate course on information systems that was 15 weeks in length. The methods of communication were two-way video/two-way audio over a fiber optic cable network. The instruction also used videotapes and a document camera for displaying graphics and three-dimensional objects. No additional information was provided regarding conversion to a distance learning format.

The DL group was n=24 undergraduates. No comparison group was provided. The dependent measure was a midterm and end of course survey on student perceptions. The researchers sought to determine whether student opinions towards distance learning change, either improving as they become accustomed to the technology or decrease for any number of reasons. The findings from a matched t-test showed only one of nine items to be significantly different, namely a decrease in the visuals being clear and easy to read but probably due to the one technical failure (faulty monitor) that occurred on the day of the second survey. There has been concern by some in the DL field that as students become more accustomed to the delivery through electronic media, they will be more demanding of its quality. On the basis of this limited study, it appears not to be the case within the restrictions of a 15-week course.

Learner satisfaction. Biner, Dean, and Mellinger (1994) conducted two investigations to identify the dimensions of learning satisfaction with a one-way video/two-way audio system. The first investigation concerned 14 televised courses to 43 off-campus locations and a mixture of graduate and undergraduate students (n=201); the second investigation concerned 13 courses to 36 off-campus locations, also with a mixture of students (n=177). No information was supplied on the course content, design, or whether it had been converted from an existing course.

The purpose of the study was to explore the factor structure of an evaluation instrument developed by Biner (1993). The second investigation served as a confirmatory analysis. A factor analysis was performed on responses to 33 items, resulting in the extraction of seven factors that accounted for 71% of the data's variance in both investigations. The seven dimensions identified are listed in Table 11 below.

Table 11.

Seven Dimensions Underlying DL Student Satisfaction (Biner et al., 1994)

Dimension	Item Loading on Factor
Instructor/instruction	.93
At-site personnel	.88
Technology	.85
Support services	.76
Promptness of material delivery	.73
Course management	.65
Communication with instructor (out of class)	.63

Social presence factors. In research on the effect of perceived social presence on student outcomes in VTT and face-to-face classes, Gunawardena and Zittle (1997) examined whether social presence is a predictor of satisfaction. The study involved an academic exercise that occurred over the course of a semester. The communication medium was computer-mediated conferencing.

The academic exercise provided a forum for graduate students at five universities to share and discuss experiences with DL research. Participation in the exercise was a course requirement. There was no mention whether the course had been previously taught in a traditional classroom and later converted to VTT. (N.B. Given the nature of the course and a

requirement for collaborative learning, the course was probably designed solely for VTT). The DL group was n=50 students. No comparison group was presented.

The dependent measures were embedded in a 61-item questionnaire administered upon course completion. Examples of variables of interest were social presence, active participation in the conference, technical training received at site, and capability of mastering computer-mediated communication, the last two being the closest to a self-assessment of learning. The overall results indicated that social presence is a strong predictor of satisfaction in computer-mediated communication. The two learning-related variables described above scored 3.2 and 4.2 respectively on a 5-point scale which appears to reflect moderate satisfaction with the technical training received at the site and reasonable satisfaction with the capability to master the computer-mediated communication technology.

Computer Conferencing

Computer conferencing offers students the opportunities to interact with each other and their instructor over computer networks (Moore & Kearsley, 1996). These interactions occur through electronic mail, bulletin boards, chat rooms, file transfers, or the transfer of images that can be annotated by means of whiteboards. These interactions can occur in real time (synchronous) or on a delayed basis (asynchronous). There have been several studies that reported the comparative effectiveness of computer conferencing in a training context, and many others that offered descriptive case studies and prescriptive overviews consisting of message traffic counts between student and instructor.

Military engineer training. In a study reported by Phelps, Ashworth, and Hahn (1991), computer conferencing was included in the delivery of training materials to reserve officers as part of a course for the Engineer Officer Advance Course. The DL component was one two-week module from a seven module Engineer Officer Advance Course. The materials used in the resident course were converted to the DL format with the breakout described in Table 12.

Table 12.

Percentage of Resident Course Materials Converted to DL Format (Phelps et al., 1991)

Media Task	Percentage
Print	41%
Team Asynchronous	20%
Computer-based Instruction	19%
Quiz/Exam/Review	14%
Team Synchronous	4%
Video	2%
	100%

The two-week module covered topics such as flexible pavement structures, asphalt production, and petroleum pipelines. The conversion of the 66-hour module to the DL format required 4,250 labor hours as described in Table 13.

Table 13.

Estimated Time for Course Conversion (Phelps et al., 1991)

Category	Staff Hours	% Effort
Course Requirements Analysis	435	10%
Course Design	163	4%
Course Development	2589	61%
CBI / Slide Conversion	812	19%
Video Tape Production	251	6%

Fourteen reservists served as the DL group and the comparison group was constituted from final exam scores (n=339) at the resident site as well as a subset of resident students (n=49) for purposes of assessing demographics and perceptions at the resident site. Dependent variables for the course were pre- and post-course student perceptions of their knowledge of the course topics, test scores, and course completion rates.

There were no demographic differences between the DL group and the comparison subset resident group. For learning outcomes, differences between the test scores of the DL students

were not significantly different from the students in residence. However, the comparison of students' self-assessment of their knowledge before and after the course showed that the DL group had a significant gain over the resident group (33% versus 12%). There was a higher course completion rate for the residence group (95% versus 64% for DL) with conflicts due to family and job cited as the reasons for attrition from the course.

Audio Technology

The importance of transmitting high quality audio for facilitating DL instruction has been identified numerous times in the literature (Garrison, 1990; Hardy & Olcott, 1995). This is true for audio/print only instruction as well as audio coupled with one-way or two-way video signals in a VTT setting. The audio technology category includes audiographics systems, which employ electronic whiteboards for the instructor to mark in useful ways and also as application sharing software which allows computer-displayed images to be transmitted to remote sites over telephone lines (as well as across the Internet). Audio represents the most common and least expensive form of synchronous interactive teletraining.

Unit clerk training. In a study of the cost effectiveness of audio teletraining for the Army National Guard, Wisher and Priest (1998) report on a three week unit clerk course delivered through study guides and audio conferencing. Students in the DL group assembled at armories in the geographic vicinity to participate in a five and a half hour daily training session using an audio bridge which connected between eight and ten remote sites (each with about six students) to the central training facility.

The course provided instruction on 47 clerical tasks such as preparing personnel qualification records or determining qualification for promotion. Of these tasks, 16 were declared critical and performance tests were administered throughout the three-week program. There were no course conversion issues as the same instructors delivered the same course to the DL and comparison groups. The only difference in training was the audio teletraining students could hear, but not see, their instructors.

Three iterations of the DL course resulted in a total sample of 118 students; the comparison group consisted of a sample of 107 students. Dependent variables were performance on a diagnostic test, performance on the first test after training on the 16 critical tasks, and completion rates. The data are presented in Table 14.

Table 14.

Results of Audio Teletraining (from Wisher & Priest, 1998)

Dependent Measure	DL Group Pass Rate	Comparison Pass Rate	t-value
Diagnostic test	9%	11%	not significant
First test after training	86%	94%	4.74*
Graduation rate	100%	100%	--

* p <.001, one-tailed test

The DL group had a slight advantage in learning performance the first time around (94% versus 86% pass rate), but the overall graduation rate was 100% for both groups. Since the DL group avoided the costs to travel and be billeted at the central training site, there was a cost avoidance of over $1,000 per student in the audio teletraining group. This translates into savings of nearly $300,000 annually if the course were to be delivered entirely by audio teletraining.

Summary of Reviewed Studies

The twenty studies reviewed portray a generally positive view of the effectiveness of DL for training applications. Our selection process resulted in the review of studies whose reported methods of communication parallel that of academia, industry and government – for example, 80% of our sample reported VTT use in comparison to 81% for the Walsh et al. (1996) review of the characteristics of DL providers. We will now assess our findings at a global level and comment on how well they address our goals in reviewing the research literature.

Our interest was in appraising the effects of three identifying features of DL on the learning outcomes. The three principal features, as offered in Moore and Kearsley's (1996) definition of DL, were course design, instructional techniques, and methods of communication. On the basis of this review, we offer the following assessment of the quality of the research literature. We categorized the degree to which each of the 20 training reports (a) Fully described, (b) Partially described, or (c) Did not mention (or relying on inferences) the three key features of DL. The results of our assessment are presented in Table 15.

Table 15.

Assessment of Completeness of Information in Research Reports

	Course Design / Conversion	Instructional Techniques	Methods of Communication
Fully described	30%	30%	50%
Partially described	30%	45%	50%
Not mentioned – inferred	40%	25%	--

Clearly there are problems with the completeness of the documentation. The descriptions of 'methods of communication,' which describe the technology that link two or more sites, was in the best condition, as all reports mentioned the technology which was used. The 'instructional technique' descriptions left something to be desired with only about a third giving a full description but one-fourth not mentioning how instruction occurred. The course design or course conversion element was in the poorest condition, with 40% not mentioning what was done to create or modify a course. In some cases, we were able to make inferences that a course was apparently newly designed or was clearly converted from an existing course. Not knowing more specific details on these key issues makes judgments difficult – was it the instructional technique, media, or great effort in converting and improving an existing course to a DL format that accounts for the improvement beyond a comparison group? Clark (1989) has often made this point in his analysis of comparing multimedia-based instruction to the traditional classroom.

CONCERNS IN EXPERIMENTAL DESIGN

The studies reviewed in this report can be classified in terms of the research design used by the experimenters to determine the success of the training program. Classification of the studies is shown in Table 16. The information presented below has been derived from Cook and Campbell (1979) and Goldstein (1993). Interested readers should consult these two sources for more detailed information on quasi-experimental designs.

Table 16.

Approximate Design Used by Researchers in the Reviewed Studies

Quasi-experimental design used	Researcher(s)
X O one-group posttest-only	Bink et al., 1995 Biner et al., 1994 Gunawardena & Zittle, 1997
X_A O X_B O two-group posttest-only	Wetzel et al., 1996b Souder, 1993
X O O posttest-only with nonequivalent comparison group	Stone, 1988
X_A O X_B O O two-group posttest-only with nonequivalent comparison group	Wetzel, 1996 Wetzel et al., 1996a
X O_1 O_2 one-group multiple posttest	Fellers & Moon, 1994 Oxford et al., 1993
O_1 X O_2 one-group pretest-posttest	Bramble & Martin, 1995 Coogle et al., 1996 Wisher & Curnow, 1998
O_1 X O_2 O_1 O_2 two-group pretest-posttest with nonequivalent comparison group	Lennon & Payne, 1997 Keene & Cary, 1990 Larson & Bruning, 1996 Phelps et al., 1991
O_1 X O_2 O_3 O_1 O_2 O_3 two-group pretest-posttest with nonequivalent comparison group (multiple posttests)	Wisher et al., 1997 Wisher & Priest, 1998 Simpson et al., 1995

X = presence of training delivered via DL
O = administration of performance or attitude measure

To say that a study of a DL training program possess *internal validity* means that it can be established that the cause or treatment (e.g., interactivity of DL instruction) was responsible for the outcomes or effects of the program (e.g., performance or satisfaction). If internal validity can not be demonstrated due to the research design or to the inability to eliminate other possible causes, then the researcher may not conclude that the treatment "worked" (i.e., caused the higher performance). Some researchers use designs in their studies that fail to eliminate many alternative reasons for the consequences of the training program. This usually occurs because of the lack of a comparison group and/or failure to obtain more than one measure of performance. Designs which use equivalent comparison groups or include pretest and posttest measures can make the results of DL studies more meaningful. Below are just a few of the "threats to internal validity" or alternative explanations for the results that can occur in studies of DL training. In each case, the researcher may mistakenly attribute success or failure to the DL instruction when it may have been due to another cause:

history - Changes in performance or attitude may be due to another specific event, other than the treatment or use of DL. For example, students may have learned the material from a source outside of class or were inspired to seek out other information outside of class.

maturation - Changes in performance or attitude measures may be due to students becoming less interested in the program or more fatigued over time.

testing - Pretest measures may sensitize students to the knowledge-based items and they may score higher on the posttest regardless of the content of the training program.

instrumentation - The subjective test scoring may change between test administrations. Also, the second administration of an objective test may be easier or more difficult than the first.

mortality - Students with less ability, motivation, or time resources may become discouraged and drop out during the program so that the average posttest knowledge-based scores are higher than the average pretest scores.

diffusion of treatments - Students in local and remote DL programs or students in the DL group and comparison groups may discuss information or share experiences thereby reducing differences between the two groups. Also, students in the "traditional" comparison group may perform differently when they learn of the additional efforts and attention paid to students in the more "desirable" DL group.

Examples

Several of the studies (e.g., Bink et al., 1995; Gunawardena & Zittle, 1997) used a one-group posttest-only design, whereby students were given a test of knowledge following the administration of the DL-based course (see Table 16). This design is generally uninterpretable due to the lack of a pretest measure of knowledge or a comparable comparison group of students who were not administered the course via DL media. For example, if students, on average, scored 90% on a knowledge-based test, it would be impossible to determine using this information whether the program was successful or not. A pretest may have revealed that students already knew 90% of the material prior to any instruction, or a comparison group of students may have scored 98%, on average, after given the instruction in a traditional classroom.

The use of pretests and comparison groups do not always reduce threats to internal validity. Often the comparison group is dissimilar to the DL group. DL students appear to be more successful, in part, because they tend to be older, more motivated and self-disciplined, are more likely to possess a college degree, and have expectations for higher grades (Gottschalk, 1996). Comparing the posttest performance measures of these students with those of typical 18 to 22-year old college students who may be taking classwork in a traditional classroom may lead to meaningless or incorrect conclusions. In addition, of the studies reviewed here, pretest and posttest measures of performance were nearly always given only one time (see Fellers & Moon, 1994; Simpson et al., 1995; and Wisher et al, 1997 for exceptions). Stronger conclusions may be drawn from designs where multiple measures are included to identify where learning occurs during the training program. This is important from a cost-savings perspective as well. Multiple measures given during a lengthy training program may reveal that DL media is most efficiently used during specific periods of training where the majority of learning occurs and that low cost alternatives, such as print or video media, may be used during other periods of the training.

Suggestions for Design

The best solution, of course, is to randomly assign students from the same population to different DL and comparison groups. This will eliminate most threats to internal validity and, if reliable and valid measures are used, can contribute to interpretable findings. Random assignment, however, is usually impossible, or at least impractical, in many military and industrial settings. It is possible, albeit difficult, in some academic settings. A reasonable

alternative was used by Miller, McKenna, and Ramsey (1993) whereby instructors alternated locations for the origination site of the broadcast so that all students participated in both the DL and comparison conditions during two consecutive classes. In this manner, each student served as his or her own comparison group. The average score on mastery tests of content delivered "live" was significantly higher (15%) than those delivered via two-way video/two-way audio media. It is worth noting that the Miller et al. study used a stronger, more interpretable design than any of the studies reviewed here, yet was the lone exception in the 57 studies reviewed by Howard (1997) where performance was lower in DL than in traditional classrooms.

In most cases where random assignment is not practical, there are several ways for researchers to plan and construct an interpretable design:

1. Administer a reliable (i.e., consistent) and valid (i.e., accurate and free of bias) pretest on the performance and attitudinal measures of interest.
2. Administer these measures to a comparable comparison group.
3. If no comparable comparison group is available, seek information about the students in terms of demographics, experience, background, and ability for use as a covariate.
4. Use multiple performance measures and administer the same measures on several occasions; be sure to use the correct data analysis procedures.
5. Use multiple pretests, especially when measuring attitudes that fluctuate over time.
6. Plan ahead to determine which threats to internal validity can be reduced through design and which threats cannot be ruled out.

Related Issues

We have concentrated on specific areas of the research literature, a representative sample of empirical studies with adequate research qualities oriented to training. We will now consider some issues and findings common to training and education: interaction between student and instructor, individual differences, and the cost-effectiveness of the use of DL media.

Interactions

Although a common belief is that "teachers teach the way they were taught", it may be more common that "teachers teach the way they learned" (Dunn & Dunn, 1979). This maxim may usually hold in the "traditional" classroom, since nearly all instructors have been educated

primarily in the traditional classroom. In a specific DL format, however, the available technology may exclude the methods by which instructors have refined over their teaching careers. For example, if certain instructors rely on the use of small group discussions or team projects in a course, they may find themselves stymied or their strong teaching skills neutralized if they teach the course via audio teletraining or one-way video / two-way audio media.

Mosston and Ashworth (1990) argued that teaching and all the in-class behaviors of instruction are governed by decision making, and that these decisions occur before, during, and after the actual classroom instruction. A good instructor, therefore, is one who makes good decisions. We would add that good decision-makers also need to be good information-seekers. This information seeking may occur before (e.g., choice of instruction materials), during (e.g., reading the puzzled looks of students), or after (e.g., obtaining useful and valid feedback from evaluation instruments) the classroom instruction. With the exception of Web-based DL technology, however, the amount and scope of information seeking may be severely reduced. This reduction of information may lead to poorer decision making and, in turn, poorer instruction. One way to increase this information is through increased interactions during learning.

Wagner (1994) defines interactions as reciprocal events requiring two objects and two actions. Such interactions foster behaviors in which individuals and groups influence one another. Interactivity, on the other hand, is considered by Wagner to be the electronic connection between the origination site and the remote sites, a technological connection rather than a behavioral exchange. Interactivity focuses on the properties of the DL configuration such as a push-to-talk microphone or an e-mail capability in computer-mediated conferencing.

Wagner (1994) identifies 13 types of interactions that can occur in DL. The hallmark of interactions is that they must result in the transfer of knowledge or a change in intrinsic motivation. The types of interactions are listed in Table 17.

Table 17.

Interactions That Can Occur in DL

Types of Interactions	
to increase willingness to engage in learning	for negotiation of understanding
to increase participation	for teambuilding
to develop communication	for discovery
to receive feedback	for exploration
to enhance elaboration and retention	for clarification of understanding
to support learner/self-regulation	for closure
to increase motivation	

In our review of the training literature, the categories of interactions were never specified in the reports. Based on our reading, it seems safe for us to assume that all of these interactions were applied during the course of training over 5,400 students in a wide variety of topics using various distance learning technologies. For future work, it would be advantageous to begin studying the relative effect on learning of the interactions as applied to different types of students, tasks, and training technologies.

Individual Differences

Although much has been written about the technology that is used to *teach* over a distance, less has been written about the students who are attempting to *learn* using this technology. It is unlikely that all students, regardless of background, experience, maturity, and other individual characteristics, learn equally well through distributed technologies. A crucial issue, therefore, is to identify which individual learning characteristics differentiate between those who learn better than others via technology.

Several such individual difference measures have been identified in the literature. Among those are three broad categories that are often used interchangeably: learning style, cognitive style, and learning strategy. There is sharp disagreement among researchers concerning which category is broadest and how each are defined (Curry, 1990; Shih, Ingebritsen, Pleasants, Flickinger, & Brown, 1998). However, since the term "learning style" appears most

frequently in the literature and is represented by the largest number of existing measures, we will reserve our discussion to this topic.

Learning style. This term can be generally defined as students' existing learning strengths or preferred manner of using their intellectual abilities (Sternberg & Grigorenko, 1997). It is presumed that learning styles are stable and relatively permanent characteristics of an individual (Garger & Guild, 1984). Although the concept has a long history in psychology and among educators, it has broadened its appeal with the advent of technology-mediated training and educational tools in academic, industry, and military settings. It is now recognized that distance learning materials must facilitate the desired learning outcomes in a way that is compatible with students' learning styles (Council of Chief State School Officers, 1995). The choice of learning style measure to use, however, is difficult. A recent review (Champagne, Dooner, & Tunney, 1998) uncovered 64 measures of learning style in print as well as several dozen learning styles available for use on the Internet. The quality and validity of many of these measures have been called into question (Curry, 1990), particularly those available on the Internet. For a review of various learning style measures see Champagne et al. (1998), Curry (1987), and DeBello (1990).

Research suggests that students whose learning styles are compatible with the style of teaching delivered in the classroom may perform higher than students whose learning styles are not compatible with such an instructional style (Furnham, 1992; Honey & Mumford, 1986; Ingham, 1991). Oxford, Park-Oh, Ito, and Sumrall (1993) classified learners of a satellite program to learn Japanese into the sensory preferences of visual, auditory, or haptic modalities. Although the researchers did not directly test performance differences, they found that students with an auditory preference were more motivated than visual students, and both were more motivated than the students with a haptic preference.

Douzenis (1998) administered both the *Group Embedded Figures Test* (Witkin, Oltman, Raskin, & Karp, 1971) and the *Learning Style Inventory* (Kolb, 1976) to masters-level graduate students in a DL course in educational research. She found that the *Group Embedded Figures Test* and one of the four factors of the *Learning Style Inventory* (accommodator) were significant predictors of achievement. We agree with the author that although the amount of total variance explained was low, the use of multiple learning style measures is a worthwhile approach. In contrast to Douzenis, a study by Shih et al. (1998) found the *Group Embedded Figures Test* to be

an unsatisfactory predictor of performance. In Web-based courses in Zoology and Biology, they found no significant differences on a standardized achievement test between students categorized as field dependent or field independent.

Self-efficacy. In addition to learning style, there are many other individual difference measures in print that have shown acceptable psychometric properties and which evaluators of DL programs may wish to administer. *Self-efficacy* is the confidence one has in being able to succeed at a particular task due to beliefs of one's skills, knowledge, and abilities (Bandura, 1982). Gist (1989) developed a popular paper-and-pencil measure of this concept and Maurer and Pierce (1998) recently developed a similar, more practical, version of the measure. High self-efficacy has been demonstrated to predict higher performance on physical exercise tasks (Bandura & Cervone, 1986), higher levels of mastery on a software training program (Gist, Schwoerer, & Rosen, 1989), and higher productivity among university faculty (Taylor, Locke, Lee, & Gist, 1984).

Motivation. Although student motivation would intuitively appear to be an important individual difference variable, it is a difficult construct to operationalize. By definition, motivation is that which energizes, directs, and sustains behavior (Steers & Porter, 1991). However, there is no single agreed-upon measure for motivation, and there exists many competing and complimentary theories containing various components, sources of motivation, and predicted outcomes. Oxford et al. (1993) found motivation to be the most important predictor of success in learning a new language in DL when using specific measure of student motivation.

To summarize the research in this area, the question is not whether learning style, in general, is good or poor predictor of student attitudes, learning, and performance. Researchers should, instead, systematically determine which of the nearly 70 existing learning style measures are the best predictors of certain criteria, and which need further validation before they may be found useful.

COST EFFECTIVENESS OF DISTANCE LEARNING

As described earlier, cost-effectiveness is viewed differently by industry, the government, and the military when compared to academia. The former seek to save travel, per diem, and productivity costs by keeping employees near the workplace rather than at a distant training site. Here, costs for procuring a DL facility and developing or purchasing courses can be justified

with training quality that is "as good as" the training received at a distant site. Examples of this were reported in Wisher and Priest (1998) in which audio teletraining of unit clerks enabled the Army National Guard to avoid costs exceeding $1,000 per trainee for a three-week course. When considering that the yearly full time equivalent training load in the Defense Department is 165,000 "students", making converting what is appropriate to convert to a DL format can reap tremendous monetary benefits. In another study we reviewed, Phelps et al. (1991) determined that converting selective modules of certain courses for Army officer training become cost-effective after ten iterations. This study was conducted years ago when the costs to supply each student with a personal computer were much higher than it is today. In industry, calls to "trim travel budgets with distance learning" (Miller, 1991) are becoming more pronounced in efforts to maintain a skilled workforce at reasonable costs.

In academia, the majority of students already reside at or near the traditional college campus. Efforts are made to convert courses to a DL format to attract students who otherwise might not attend that institution because of travel or time constraints. The educational institutions do not have to pay travel or per diem costs, so being "as good as" the traditional classroom is not necessarily a sufficient justification for course conversion. Rather, training must add educational value and be flexible and of high quality in order to be "better than" the programs of other educational institutes.

The competition among educational providers is changing the economics of higher education as the supply-side of DL challenges the industrial-age traditions of education. There is a recent recognition of the importance of attracting not only students from within the worldwide market of learners, but also attracting groups of individuals who find travel to campuses to be difficult or inconvenient. These groups include those who are homebound because of child care responsibilities or a disability, full-time employees involved in life-long learning programs or retraining for a career change, and in-service training for teachers and educators. In addition, universities have discovered the financial advantages of delivering DL-based professional masters programs to a new market of students. Unfortunately, it is difficult to assess the costs of DL training courses in academia due to the variability of technologies used as well as the myriad relevant costs (e.g., marketing, faculty, teaching assistant, and production manager salaries, technical support). It is not unusual for a single training program to be simultaneously delivered via three or more technologies (e.g., Web-based, VTT, videotape) or in both synchronous and

asynchronous fashion, depending on the needs or resources of the students. Therefore, the complex question of the cost-effectiveness of DL technology may have to be answered on an individual course or program basis.

FUTURE WORK

Learning and Training Outcomes

One recommendation that arises from our review of the research involves the careful, systematic use of learning and training outcomes and the measures that represent those outcomes. Evaluation of training programs is primarily conducted to determine if training objectives were achieved (Campbell, 1988) as well as whether accomplishing those objectives enhanced performance on the job (Kraiger, Ford, & Salas, 1993). The most popular model used to evaluate training programs has been that proposed by Kirkpatrick (1994) which consists of trainee reactions, learning, behavior, and organizational results. Also, Kraiger et al. (1993) have developed a multidimensional perspective to learning outcomes that is firmly couched in existing theories and taxonomies (e.g., Bloom, 1965; Gagne, 1984). Their classification integrates three learning outcomes (cognitive, skill-based, affective), with their representative learning constructs (e.g., verbal knowledge, attitudes, motivation), and suggests particular methods to successfully measure these constructs (e.g., self-report, protocol analysis, recognition and recall tests). This framework of finding appropriate measures for the appropriate outcomes that represent the critical constructs is one example of the careful consideration of theory and research when designing evaluations of DL programs.

Evaluation

The evaluation of many DL programs currently delivered by academic, industrial, and military institutions are much like autopsies. Once the class is over, they attempt to discern what went wrong. Although educators have the technology to deliver courses to nearly every location in the world, they usually rely on end-of-training, paper-and-pencil measures of student attitudes or performance that often are of questionable validity and reliability. These measures are given too infrequently to make immediate improvements in the delivery of training. What is needed are reliable and valid measures of performance which can be immediately administered to the students and quickly returned to the instructor, while the class is still in session. This would

provide quick feedback to the students, demonstrate to students that they are an important part of the training process, and help to quickly improve the delivery of training with minimal time expenditure from the instructor (Champagne, 1998).

Successful DL programs will continue to require a stronger and more comprehensive evaluation component. Evaluation is unlikely to be successful if performed as an "add on" or conducted by someone without the proper skills in evaluation theory and methodology, experimental and quasi-experimental design, criteria development, measurement theory, and statistical analysis

The Future of DL in Academia and Industry

With the increasing reliance on technology, there is little doubt that the Internet (and its future offspring) will continue to be an important resource in education and training. Many have suggested that the use of this technology will soon allow private industry to challenge universities for the delivery of education. Indeed, online law schools already exist which feature prestigious faculty from various universities. Students and professionals will soon be no longer constrained by time or place for education. Within a short time, nearly every major learning institution and many private organizations will be able to educate and train people at a distance, and students from across the globe will select where to send their tuition dollars based on factors other than location. Training and education programs that are long on technological gimmickry but short on foundational research as to why that technology would be effective for successful learning will not sustain their programs in a competitive market.

The decreasing costs and increasing popularity of information technology has dramatically changed the delivery of training in the past decade. However, the technology has quickly outpaced the theory that supports its effectiveness, and the application of technology has surpassed the evaluation of that technology. There is no body of research that meaningfully unites training objectives, training content, instructional style, and the DL media. What is needed is empirical information and systematic research which would help instructors design their courses to incorporate the most appropriate technology based on the course content, the type of student attending the course, and the type of teaching style used by the instructor. Crawford and Suchan (1996) drew a similar conclusion in their call for systematic selection of "instructional media for specific learning applications that places priority on the desired learning

outcome and the media required to support the instructional techniques to attain that outcome" (p. 36).

SUMMARY REMARKS

The studies reviewed in this report are organized in Table 16 in order of least interpretable designs to most interpretable designs. The nine studies that used only posttest measures of performance or student attitudes, some with a nonequivalent comparison group, are difficult to interpret. Without a pretest measure, many threats (e.g., maturation, history, mortality) to the internal validity of the study cannot be ruled out. That is, the scores on the posttest may be due to other factors besides the DL media. Stronger designs are those which use multiple posttests, which may help to rule out instrumentation or maturation effects as an alternative explanation, and those designs using a comparison group, which may help to rule out mortality and history effects.

Several conclusions may be drawn based on the designs of these studies. First, because random assignment of students to the DL and comparison groups was not possible, none of the studies, individually, can reject the possibility that the positive results were due to other factors besides the use of DL media. Some could argue, however, that the uniform positive results, aggregated across all studies, would suggest that the superiority or equivalence of the DL groups is a meaningful finding. Future studies which allow random assignment of students to groups or that measure performance while students alternate between groups (e.g., Miller et al., 1993) would allow more conclusive results to be drawn.

Second, the use of "convenience samples" to serve as comparison or DL groups makes it difficult to draw meaningful conclusions. In most cases, there are specific reasons (e.g., location, availability of technology, convenience, and job requirements) why students attend training programs via DL media. There may be fundamental pre-existing differences between students who choose to attend the training program or choose a DL-based training program over a non-DL based training program that are reflected in the measures of performance.

Third, nearly all the studies reviewed suggested that differences between groups was solely due to the DL media used rather than to individual student differences such as learning style, self-efficacy, or motivation. In a traditional classroom, most instructors realize that not all students learn best using the same method. Some students prefer a hands-on approach; some

prefer to work with teammates; others gain knowledge by just reading the text themselves; and still others find that real-life examples or stories from their instructors are most informative. This recognition of individual differences in the traditional classroom should extend to the DL classroom. Future studies should incorporate measures of individual differences to avoid ambiguous or erroneous evaluation results that assume all students in a training program possess the same skills, knowledge, and abilities.

This report examined the research methodologies, experimental designs, variables, comparison groups, sample sizes, and other factors that lead many to conclude that distance learning is an effective alternative to the traditional training classroom. Based on our review of the literature, it is difficult to identify with precision why DL appears to be successful: was it the effort in course design? the interactions made possible by method of communication? the instructional technique? Details in the literature are usually incomplete. The interpretability of the training studies varies. Unfortunately, researchers are often bound by the realities of their test environments. With improved designs and stronger controls, the research community should better be able to inform policy makers, training managers, and practitioners where best to invest in distance learning.

As the Army pursues it goal to convert over 500 courses to a DL format and install hundreds of DL classrooms around the world, efforts should be taken for stronger evaluations of the effectiveness of DL. In particular, stronger experimental designs should be followed, when practical, to eliminate alternate explanations as to why a DL course was effective. Such stronger designs will allow a better understanding of the relative return on a training investment – from the course design, the interactions made possible by the training technology, or the instructional techniques inherent in a particular distance learning technology.

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