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The Use of Videoteletraining to Deliver Hands-on Training: Concept Test and Evaluation

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13. ABSTRACT *(Maximum 200 words)*

The objective of the work was to test the feasibility of using videoteletraining (VTT) to deliver hands-on training. This objective was addressed by determining the effects upon dependent variables of student participation in (1) live versus VTT instruction and (2) two alternative laboratory strategies. VTT was effective for lecture, discussion, and hands-on demonstration portions of training as indicated by the final examination, student course evaluation, and observations. VTT classroom design was successful and may serve as a model for others. The most difficult aspect of hands-on VTT is the laboratory, during which the instructor typically works closely with students to demonstrate procedures, supervise, assure safety, and certify student performance. Two different strategies for handling remote laboratories were tried during the study: (1) having students view videotapes of laboratory procedures instead of participating in a laboratory and (2) having a facilitator conduct the laboratories off-line. Students who observed videotapes instead of participating in a laboratory took longer to perform on all performance test tasks and performed less accurately on two out of three tasks. The second laboratory strategy was more successful. Observations indicated that the learning processes occurring in remote laboratories were very similar to those of traditional live laboratories.

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FOREWORD

This technical note describes work conducted as part of the Navy Personnel Research and Development Center's Communication Networks in Training (CNIT) project in the general area of remote-site training. The CNIT project is one part of the Schoolhouse Training product line and falls under the Personnel and Training Technology (NP2A) Block of the 6.2 Mission Support Technology Program Element 0602233N (Work Unit RM33T23.02). The work was performed under the sponsorship of the Office of Naval Technology. The objective of the project is to find more cost-effective ways to train personnel who are geographically remote from training resources. The project has been exploring the use of new communication technologies to export training to geographically-remote students. Among these technologies are computer networking, instructional TV, videotape, audiographics, videographics, and other media. This technical note describes a laboratory study involving 215 Navy students which investigated the feasibility of using videoteletraining to deliver hands-on training. The findings have direct implications for the design of future distance education systems in the Navy and elsewhere.

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

J. C. MCLACHLAN
Director, Training Research Department

SUMMARY

Problem and Background

A requirement exists to train Navy personnel who are geographically remote from training resources. Previous research and development work has demonstrated that videoteletraining (VTT) can be an effective and cost-effective method to deliver training electronically to remote Navy personnel. To date, VTT has been limited to the delivery of lecture-based training. The utility of VTT would increase if it could be used to deliver hands-on training.

Objective

The primary objective of the project is to find more cost-effective ways to train personnel who are geographically remote from training resources. The objective of the work described in this technical note was to test the feasibility of using VTT to deliver hands-on training.

Method

The method included steps to develop a research plan, prepare for VTT, and collect and analyze data.

Results

VTT was effective for lecture, discussion, and hands-on demonstration portions of training as indicated by the final examination, student course evaluations, and observations.

VTT classroom design was effective for hands-on training and may serve as a model for use by others designing VTT classrooms for hands-on training.

The most difficult aspect of hands-on VTT is the laboratory, during which the instructor typically works closely with students to demonstrate procedures, supervise, assure safety, and certify student performance. Two different strategies for handling remote laboratories were tried during the study: (1) having students view videotapes of laboratory procedures instead of participating in a laboratory and (2) having a facilitator (instructor surrogate) conduct the laboratories off-line. Students who observed videotapes instead of participating in a laboratory took longer to perform on all performance test tasks and performed less accurately on two out of three tasks. Viewing a videotape is no substitute for participating in a laboratory, though it is probably better than no laboratory at all. The research provided some evidence that videotapes are more effective than live demonstrations in helping students learn to perform procedural steps that do not in themselves provide feedback on their correctness.

The second laboratory strategy was more successful. Observations indicated that the learning processes occurring in remote laboratories were very similar to those of a live class. Additional research is required to determine whether or not this strategy would be generally effective for a variety of content areas.

Recommendations

1. The Chief of Naval Education and Training should ensure that VTT classrooms used to originate courses with a significant hands-on training component are designed to satisfy the special requirements of these courses. Among the requirements are additional storage space for training aids, an open and flexible floor plan, a demonstration area covered by a separate camera, an instructor's workstation, and a cordless microphone to provide the instructor with mobility.

2. The Chief of Naval Education and Training should employ the most practical and effective strategy known at this time for conducting hands-on laboratories at remote sites: equip remote sites with laboratory equipment and have a facilitator conduct the laboratories off line. While this laboratory strategy is workable, other less costly strategies should be investigated further.

3. The Chief of Naval Education and Training should originate a Problem Description and Need Justification for research to test and evaluate alternative strategies for conducting VTT hands-on laboratories. Among these strategies are remote presence, the use of on-board training packages to allow supervisors to train students on the job, and other strategies that may be feasible and effective.

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INTRODUCTION

Problem and Background

A requirement exists to train Navy personnel who are geographically remote from training resources. Previous research and development work has demonstrated that videoteletraining (VTT) can be an effective and cost-effective method to deliver training electronically to remote Navy personnel (Rupinski, 1991; Rupinski & Stoloff, 1990; Simpson, Pugh, & Parchman, 1990, 1991; Stoloff, 1991). To date, VTT has been limited to the delivery of lecture-based training. Much of Navy training requires students to develop hands-on skills (e.g., to disassemble, adjust, calibrate, or otherwise manipulate machinery, equipment, devices, or other physical objects using tools or test equipment). The utility of VTT would increase if it could be used to deliver hands-on training.

Objective

The primary objective of the Communication Network in Training (CNIT) project is to find more cost-effective ways to train personnel who are geographically remote from training resources. To meet this objective, the project has conducted a VTT demonstration project; a field survey of VTT systems in public education, industry, and the military; and a series of laboratory studies of variables influencing VTT user acceptance and training effectiveness. This project work is reported in Simpson et al. (1990, 1991) and Pugh, Parchman, and Simpson (1991). The objective of the work described in this technical note was to test the feasibility of using VTT to deliver hands-on training.

Research Issues

Instructional TV (ITV) systems have traditionally been used to deliver lecture-based training. There have been few attempts to use ITV for hands-on training. Conducting lecture-based training with VTT requires an instructor to stand before a camera, speak into a microphone, and present visual aids using some form of an extra or easel camera. Instructor-student interaction consists of questions, comments, discussion, and other verbal discourse picked up with microphones and projected with public address systems. These processes are relatively straightforward.

Courses involving hands-on training usually include lectures and discussion so they require everything that lecture-based VTT does. In addition, hands-on courses generally include demonstrations with training aids of varying complexity and hands-on laboratory sessions during which the instructor works closely with students to (1) demonstrate procedures, (2) supervise students, (3) assure safety, and (4) certify student performance. Each of these additional requirements poses a challenge to VTT. First, the classroom must be adapted to permit effective demonstrations, or alternative methods of delivering demonstrations must be developed. Second, alternative methods must be developed to handle laboratories. In this connection, several strategies are possible. The simplest strategy is to eliminate the laboratory from training at remote sites. On its face, this is undesirable in terms of student skill mastery and would probably be unacceptable to the Navy training establishment.

A second strategy is to equip remote sites with additional audio and video equipment to provide the instructor with a sort of remote presence. This is probably not practical with present technology. Moreover, an instructor who was not physically present could not guarantee student safety.

A third strategy is to have a facilitator conduct the laboratories off-line. This strategy is practical to the extent that the Navy can afford to equip remote classes with the necessary laboratory equipment and subject-matter experts to act as facilitators. If the laboratory requires costly, complex, or difficult to maintain laboratory equipment and/or the required facilitator's skills begin to approach those of a trained instructor, the utility of this strategy breaks down.

A fourth strategy is to develop on-board training packages that can be administered by the student's supervisor on the job rather than in formal training. This strategy is probably practical, though it would transfer training burden to ship's crew and reduce training quality control.

One may envision other strategies as well. Thus, a key issue in assessing the feasibility of hands-on VTT is the choice of laboratory strategy. The research presented in this technical note investigated two laboratory strategies: (1) having students view videotapes of laboratory procedures instead of participating in a laboratory and (2) having a facilitator conduct the laboratories off-line.

METHOD

Overview

The method included steps to develop the research plan, prepare for VTT, and collect and analyze data.[1] These steps are described below.

Research Plan

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

Research Objectives

The objective of the work was to test the feasibility of using VTT to deliver hands-on training. Feasibility is assessed in terms of training effectiveness and acceptance by students and instructors. The baseline for comparison is traditional live instruction. It was not expected that any VTT technology would improve training effectiveness or acceptance; parity with live instruction would validate the technology. This objective was addressed by determining the effects upon dependent variables of student participation in (1) live versus VTT instruction and (2) two alternative laboratory strategies.

A secondary objective was to assess the relative training effectiveness of 1-way video with 2-way audio (1V/2A) vs. 2-way video with 2-way audio (2V/2A). The resulting research was a

[1]The assumptions and simulation requirements underlying the VTT laboratory and the VTT laboratory itself are described in detail in Simpson et al. (1991).

partial replication, with a hands-on course, of earlier research with lecture-based training as reported in Simpson et al. (1991).

Research Design and Independent Variables

The research consisted of two related experiments.

Experiment 1. Experiment 1 used two independent variables in a 2 X 2 design. Independent variables were classroom (local or remote) and type of VTT technology (1V/2A or 2V/2A).

Experiment 2. Experiment 2 used a two-group design. The independent variable was type of laboratory strategy (laboratory or video aid). Subjects in the laboratory (control) group completed a traditional hands-on laboratory and then received a performance test. Subjects in the video aid (experimental) group viewed a videotape of lab procedures, without completing a hands-on laboratory, and then received a performance test.

Dependent Variables

Dependent variables were student performance on a written final examination, student performance on performance tests, and student attitudes on several different factors as reflected in written course evaluations. The methods and instruments used to collect these data are described below.

Data Collection Methods and Instruments

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

Performance tests: Performance tests were developed and administered to a random sample of 62 students following training. Performance tests were used as a dependent measure only for experiment 2. The testing procedure was time and personnel intensive, which made it impractical to administer tests to all students. The performance tests assessed student speed and accuracy in performing three laboratory tasks: watertight door chalk test, marine strainer disassembly/assembly, and door dog maintenance. Damage Control Petty Officer (DCPO) instructors recommended that these tasks be used for performance testing because they represented a perceived range of difficulty from chalk test ("easy") to door dogs to strainer ("difficult"). Performance tests were administered by an instructor to individual students in a secure area. The performance testing procedure, scoring rules, student instructions, and performance tests are contained in Appendix B. The performance testing procedure is described in greater detail in the Classroom Procedures subsection.

Written final examinations: Written final examinations were administered to 215 students at the end of the course. The exams were taken "closed book" and consisted of 50 4-choice multiple-choice items. One form of the final was used throughout research.

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

Observations: Navy Personnel Research and Development Center (NPRDC) observers moved between classrooms during training and maintained a written log of significant class events.

Instructor debriefings: Instructors were debriefed by NPRDC researchers at the end of each week and comments were recorded in a written log.

Subjects

Subjects were Navy active duty personnel in a variety of ratings undergoing training required by their duty position. Ranks ranged from E-2 to E-8, with the majority of students E-4 to E-6; mean rank was E-5. Students were assigned to a classroom (local or remote) by instructors, who attempted to balance the relative sizes and seniority of local and remote classes. Each classroom typically contained about 18 students.

Data Collection

Data were collected over a 6-week period beginning in June 1991. Data were collected for a single 2-day class during each week. The first 3 weeks of data collection simulated 2V/2A and the final 3 weeks simulated 1V/2A.

Preparation for VTT

Training Course Selection

The research was conducted using the Fleet Training Center's (FTC) 2-day Divisional DCPO Indoctrination course (J-495-0400). The DCPO course was recommended by Commander, Training Command, U.S. Pacific Fleet (COMTRAPAC), with the concurrence of the FTC. It was an ideal candidate for research in VTT hands-on training because it is short, in high demand, has high student throughput, and uses class processes typical of many other hands-on courses. It includes lectures, written tests, demonstrations with various training aids, presentation of visual aids (transparencies, videotapes), and laboratories during which students disassemble, adjust, reassemble, and test damage control equipment. No performance testing is administered during traditional DCPO courses and we had no reason to expect the written test to highlight performance differences among students as a function of live vs. VTT; hence, we developed a performance test (Appendix B).

The course differs from previous lecture-based courses we have conducted research with primarily in terms of its requirement for demonstrations with many large training aids (e.g., hatches) and requirement for hands-on laboratories.

Classroom Procedures

Training and the classroom itself had to be adapted for VTT. The adaptation procedure followed is described in Simpson (in press). Classroom procedures were constrained by the audio/video equipment used, classroom design, and the requirement to conduct training and manage two classes simultaneously. The classroom floor plan is shown in Figure 1. The classroom was equipped with two stationary instructor cameras, one pointed at the lectern area and the second at the demonstration area (to the instructor's left, when facing the class). Instructors had to restrict their movement left and right to remain in the picture frame. The instructor was provided with an easel camera, which was used to present visual aids and for writing (instead of a writing board). A video switch enabled the instructor to select the camera or other video source.

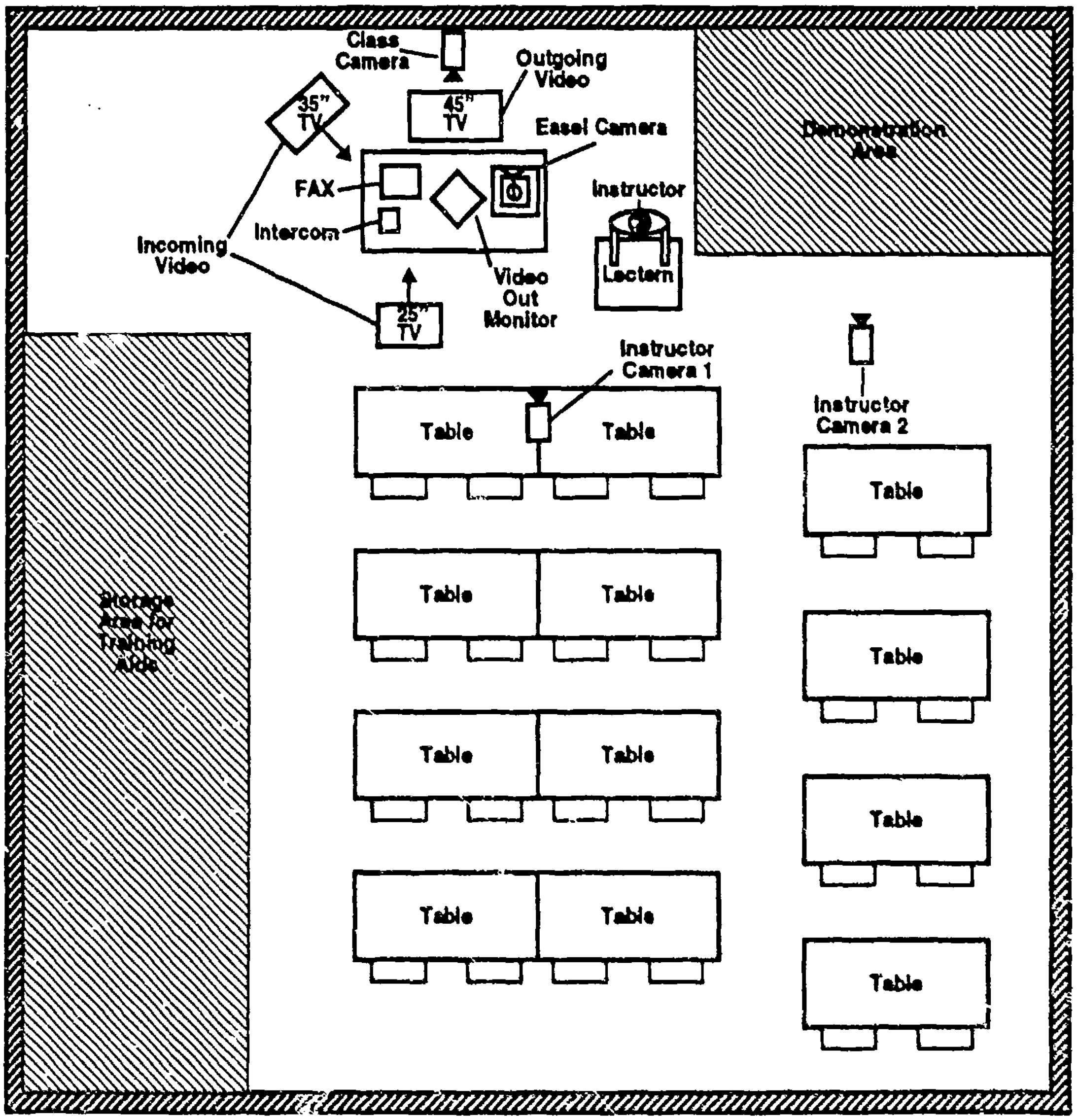

Figure 1. VTT classroom floor plan for damage control petty officer course.

No modifications were made to the content of lectures, class written materials, or written tests, though performance tests were selectively used. VTT and live course length were identical. Viewgraphs used in the live class were converted to hardcopy form to improve their appearance on TV displays.

Demonstrations and laboratories had to be modified for VTT. The traditional live class was conducted in a classroom with many large, stationary training aids (e.g., vertical ladder, various hatches, bulkhead-mounted marine strainer) located about the room. During the class, the instructor would move from training aid to training aid to conduct the demonstration. Capturing the instructor's picture on TV would have required a dedicated camera at each demonstration position or a camera operator with movable camera. Since both alternatives were impractical, two strategies were used to support the demonstrations: (1) the instructors fabricated a portable, multi-purpose training aid that could be rolled on and off camera in the VTT classroom's demonstration area and (2) some demonstrations were videotaped and later presented to the class instead of live demonstrations.

The most challenging aspect of hands-on VTT was to adapt the laboratories for remote-site delivery. During traditional live courses, the instructor strolled the laboratory stations and worked closely with students to demonstrate procedures, supervise students, assure safety, and certify student performance. Our observations of laboratories indicated that instructor demonstrations were usually incomplete but that students could master laboratory procedures anyway by working with peers, relying on prior experience, or using trial and error.

During the research, the traditional laboratory procedure was followed with students in the local class. However, this could not be done at the remote class since no instructor would be physically present there. The compensatory strategy used in the remote class had three elements: (1) duplicate laboratory equipment, (2) videotaped laboratory demonstrations, and (3) facilitator to supervise laboratory, assure safety, and certify performance. The duplicate laboratory equipment permitted remote students to gain hands-on experience, the videotapes provided demonstrations in the absence of a live instructor, and the facilitator performed the instructor's three remaining laboratory functions. The facilitator's role was defined as that of a qualified DCPO (i.e., a subject-matter expert) but not an instructor; thus, the facilitator answered questions but did not engage in formal instruction during the laboratory.

Videotapes were made of the instructor performing laboratory demonstrations. The videotapes covered six tasks: (1) marine strainer disassembly/assembly, (2) watertight door chalk test, (3) door dog maintenance, (4) battle lantern disassembly/assembly, (5) ladder maintenance, and (6) watertight scuttle maintenance. The tapes were made based on Personal Qualification Standards (PQS) procedures and were accurate and complete; hence, they provided a more systematic and comprehensive demonstration than the typical live demonstration. Each of the videotapes averaged 5 minutes in length. They were produced in a period of approximately 3 weeks by a team of three DCPO instructors and a crew of audio-visual specialists from NPRDC. The instructors created scripts for each video based on PQS procedures. They made arrangements to shoot the videos on board ship and in the DCPO classroom. NPRDC audio-visual specialists made videotapes of the instructors performing the procedures on camera and later provided a VHS master allowing the instructors to identify editing requirements. The instructors then worked closely with audio-visual personnel during editing and recording of a sound track. In part, this effort was conducted to test the feasibility of "grass roots" video production. The resulting videos were simple but technically accurate, and were produced at a fraction of the cost of professional quality video.

In traditional DCPO training, the instructional sequence is (1) lectures and demonstrations, (2) laboratory, and (3) written final examination. During experiment 1, students in both local and remote classes followed this procedure, though laboratories in the local class were overseen by an instructor and those in the remote class were overseen by a facilitator.

During experiment 2, students in the local class went through the instructional sequence (1) lectures and demonstrations, (2) laboratory, (3) performance test, and (4) written final examination. Students in the remote class went through the instructional sequence (1) lectures and demonstrations, (2) videotaped demonstrations, (3) performance test, (4) laboratory, and (5) written final examination. Note that students in the remote class were performance tested before they received any hands-on training in the laboratory. Performance testing involved individual testing of students by an instructor and was very time and labor intensive. For this reason, only a sample of students (62) was tested. Note also that the written final examination tested student knowledge of information presented during lectures and demonstrations, not laboratories, so that final examination scores should not be affected by the differing laboratory experiences of local and remote classes.

For lectures, traditional instructor-student interaction procedures were modified for VTT. The instructor made seating charts of both classrooms and systematically alternated questions between classrooms. In all research conditions, students were required to identify self by name, pause to be recognized by the instructor, and then asked their question. The instructor would sometimes repeat a question before answering.

The written final examination was administered and scored in the local classroom by the instructor and in the remote classroom by the facilitator; results were transmitted from remote to local classroom via facsimile machine.

During experiment 2, performance tests were administered and scored by five different instructors in six different secure testing areas. Tests were administered by instructors who had no knowledge of whether the student was from the laboratory or video aid group. All instructors followed the performance testing protocol contained in Appendix B.

Instructor Training

Three different instructors delivered training during the experiment. Each instructor conducted two classes, with the assistance of a second instructor playing the role of a facilitator at the remote classroom. All instructors had graduated from Navy instructor training school and were qualified to teach damage control. NPRDC research personnel worked closely with the instructors during an informal 1-week training period. Instructors were familiarized with the audio and video equipment and practiced equipment operation and class procedures. The total training period per instructor was approximately 2 days, most of it devoted to practice teaching. None of the instructors was given or had previously received training in camera presence, articulation, graphics production, or other skills of TV professionals.

VTT Laboratory

The cameras and other equipment used in the VTT laboratory are described in detail in Simpson et al. (1991). The classroom floor plan was shown earlier in Figure 1. Students sit at tables, with two chairs per table. Each table is equipped with low-profile sound-activated microphone. Large-size TV displays are used: 45" rear projection TV as main display, 35" tube as secondary display. Tables are arranged in amphitheatre fashion so that all students are seated within a 90-degree arc originating from the center of the main TV display to assure an adequate view. The secondary TV display is located to the left of the primary display. The primary display shows outgoing video in the local class and incoming video in the remote class. The secondary display shows students in the other class.

Each classroom has four different TV cameras: (1) instructor lectern, (2) instructor demonstration area, (3) easel camera, and (4) class. A multi-channel video switch is used to select which camera's signal to send to the other classroom. The instructor's cameras are suspended above the second row of tables. The class camera is located above and behind the main TV display.

The instructor wears a continuously-on, wireless, clip-on lavaliere microphone and stands behind a lectern at the front of the classroom to the left of the primary TV display. The video switch (a small panel with seven push-buttons) is attached to the side of the lectern so that the instructor can reach down and switch cameras with the left hand. On the table to the left of the instructor are an easel camera and a TV monitor used for orienting graphics on the easel camera. A 25" TV display on the floor before the first row of students faces the instructor and shows incoming video from the remote class. Each classroom is equipped with a facsimile machine and telephone connected to other classroom(s) via ring-down telephone circuits.

The classroom design is similar to the one we have used for lecture-based instruction with the following exceptions:

1. Open floor space is provided on the left side of the room for storage of training aids.

2. First row of students is moved back to provide space for instructor to perform demonstrations with training aids.

3. Movable lectern is provided.

4. Instructor workstation is simplified.

5. Instructor is provided with cordless microphone (needed for additional mobility).

RESULTS

Experiment 1

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

Final Examination

A total of 215 students completed the final examination. Final examination scores as a function of classroom (local or remote) and VTT technology (1V/2A or 2V/2A) are summarized in Table 1. A 2-way analysis of variance was conducted using classroom and VTT technology as independent variables and final examination score as the dependent variable. None of the main effects or interactions was statistically significant. Student performance was not significantly affected by whether students were present in the local or remote classroom. Test scores were slightly higher with 2V/2A technology as compared to 1V/2A, but this difference was not statistically significant either.

Table 1

Final Examination Scores by Classroom (Local or Remote) and VTT Technology (1V/2A or 2V/2A) (Numbers are percentages) (*N* = 215)

	Scores (%) by Classroom		
VTT Technology	Local	Remote	Overall
1V/2A	89.84 (*N* = 62)	89.54 (*N* = 65)	89.69 (*N* = 127)
2V/2A	94.67 (*N* = 42)	90.83 (*N* = 46)	91.23 (*N* = 88)
Overall	90.58 (*N* = 104)	90.07 (*N* = 111)	90.32 (*N* = 215)

Experiment 1 is a partial replication of work reported in Simpson, Pugh, and Parchman (1991). That research investigated the relative training effectiveness and user acceptance of live instruction and six different alternative VTT technologies for lecture-based training. The present study enabled the extension of that research for the lecture and discussion portions of a hands-on training course. The earlier research indicated that student performance was comparable in live classrooms and VTT classrooms using 1V/2A or 2V/2A.

Course Questionnaire

Student attitudes were measured with a post-course questionnaire (Appendix C) which contained a series of statements to be rated, multiple-choice questions, and open-ended questions. Questionnaires were completed by 199 students. The results are collapsed across technologies (1V/2A and 2V/2A) and described below in terms of classroom (local or remote), the variable of primary concern in experiment 1. We administered a closely-related questionnaire to students during previous research and the results are presented in Simpson et al. (1990, 1991). Since the present findings closely match those reported previously, the following discussion is brief.

Student Ratings. The statements to be rated fell into six categories (instructor, audiovisual aids, tests and homework, training aids, labs, and overall assessment of instructor and course). Statements were rated on a 5-point scale with a midpoint of 3. Mean ratings were computed for local and remote classrooms and are shown in Table 2. The majority of ratings on all items fell well

Table 2

Attitude Measures on Student Course Questionnaire (Scale 1-5)
(*N* = 199)

Question	Responses[a] by Classroom		
	Local	Remote	Local-Remote
Instructor			
1. Instructor prepared for class.	4.4	4.2	0.2
2. Instructor presented lesson clearly.	4.4	4.2	0.2
3. Instructor answered student questions.	4.5	4.3	0.2
4. Instructor encouraged student participation.	4.4	4.3	0.1
Audio-visual Aids			
5. Image on video screen was large enough.	4.0	4.2	-0.2
6. Image on video screen was clear enough.	3.9	4.1	-0.2
7. Audio from other class was loud enough.	3.7	3.5	0.2
8. Audio from other class was clear enough.	3.6	3.7	-0.1
Tests/Homework			
9. Test questions were clearly written.	4.2	4.1	0.1
10. Test questions related to course.	4.5	4.3	0.2
11. Test questions were fairly graded.	4.5	4.4	0.1
Training Aids			
12. Training aids supported instruction.	4.5	4.3	0.2
13. Training aids were used effectively.	4.5	4.4	0.1
14. Details of training aids could be seen clearly.	4.5	4.3	0.2
Labs			
15. Labs helped me understand course material.	4.5	4.5	0.0
16. Labs helped me learn to perform tasks.	4.5	4.5	0.0
17. There were enough labs to cover key topics.	4.4	4.4	0.0
18. Job performance sheets were effective.	4.2	4.1	0.1
19. Instructor/facilitator provided help during labs.	4.6	4.5	0.1
20. Videotapes during labs were valuable.	N/A	4.1	N/A
Overall			
21. Compare instructor with others in past.	4.0	4.0	0.0
22. Compare course with others in past.	3.9	3.7	0.2

[a]Responses range from 5 = outstanding to 1 = unsatisfactory.

above the midpoint on the rating scale; most students gave positive ratings to the dimension being measured. Differences between local and remote classrooms were small and show no interesting patterns. The main thing they show is that, regardless of whether students were in the local or remote classroom, they were positively disposed toward several different aspects of the VTT learning environment. One possible problem area was audio (questions 7, 8), which also parallels previous findings.

Figure 2 shows student responses to question 24. Most students felt either that VTT had no effect on opportunities to ask questions or provided more opportunities. However, in remote classes, overall, 24.2 percent of students felt that VTT had provided fewer opportunities.

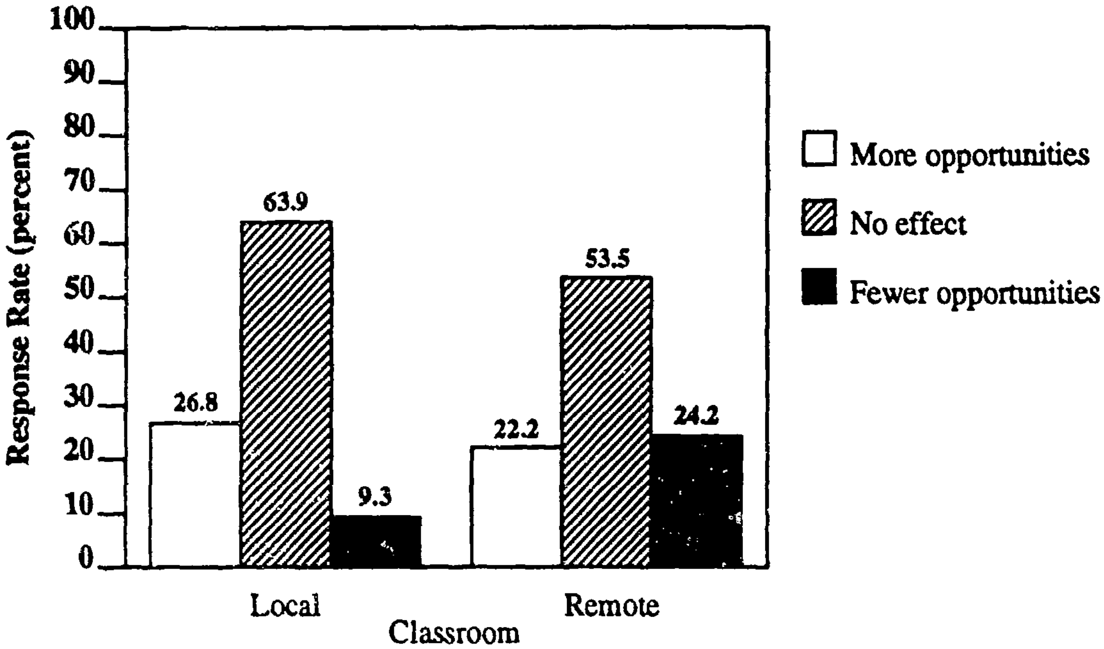

Figure 2. Student responses to question 24 (How did the VTT method of instruction affect your opportunities to talk to the instructor or ask questions, as compared to traditional methods of instruction?).

Figure 3 shows student responses to question 25. Nearly one-half of students in local and remote classes expressed preference for traditional instruction. Interestingly, students in the remote class were about twice as likely to prefer VTT as students in the local class.

Figure 4 shows student responses to question 26. Most students either felt that VTT had no effect on learning or improved learning.

Student Comments. Student comments were not submitted to formal analysis as the research was similar to previous research we have conducted (Simpson et al., 1990, 1991) and would be expected to yield similar results.

Observations

As in previous research, we observed that instructors gained skill and confidence in the VTT classroom rapidly. All functioned effectively within a few hours, and became comfortable and skilled before the camera in about 2 weeks.

The processes occurring during laboratories in local and remote classrooms were similar. The instructor generally played a more active role in the local classroom than did the facilitator in the

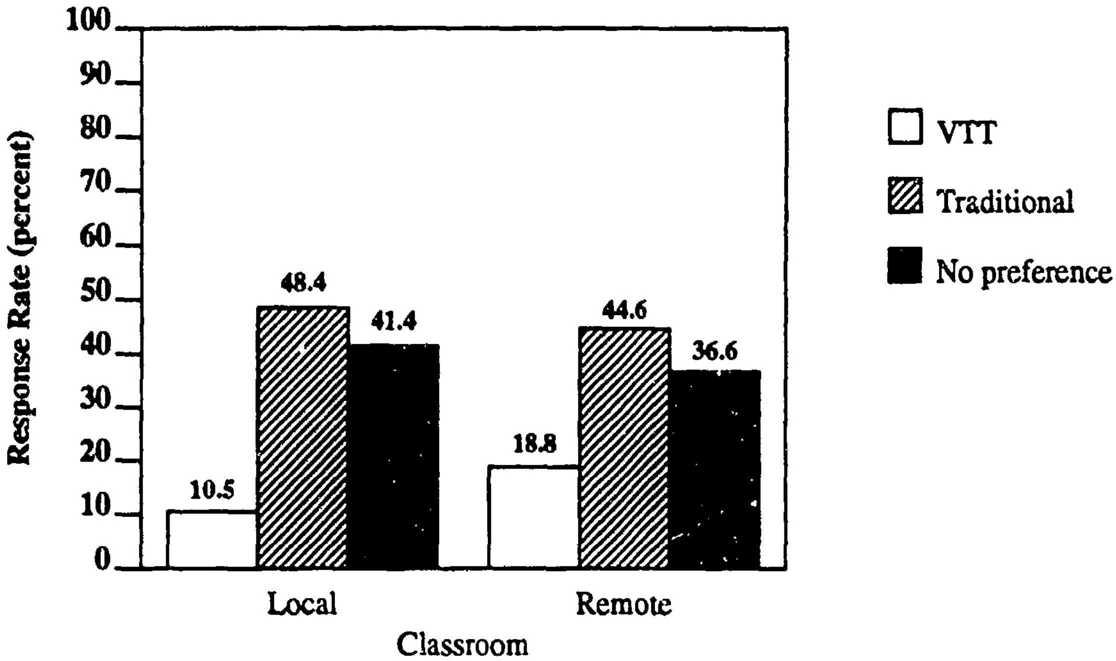

Figure 3. Student responses to question 25 (Which method of instruction would you have preferred for this course?).

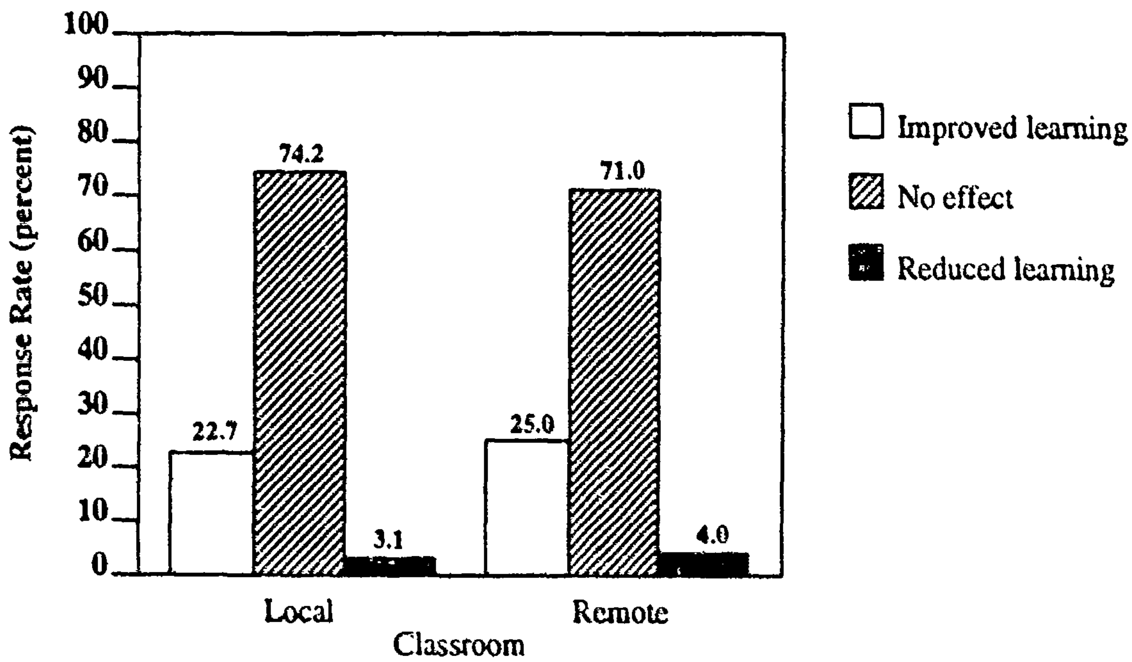

Figure 4. Student responses to question 26 (How did the participation of student at other site(s) affect your learning during this course?).

remote. In the local classroom, the instructor moved from laboratory station to station, performed brief demonstrations, and answered student questions. In the remote classroom, the facilitator moved from station to station, answered questions, and tried to be helpful, but did not conduct structured training. In both classrooms, the amount of time the instructor or facilitator spent at any station was small. Most students had prior training and experience performing the laboratory tasks and did not need much help from the instructor. Students appeared to rely more on prior experience or help from peers than the instructor/facilitator.

Experiment 2

As noted, students in the laboratory group completed a traditional hands-on laboratory and then received a performance test. Students in the video aid group viewed a videotape of laboratory procedures, without completing a hands-on laboratory, and then received a performance test.

Performance test speed data are given in Table 3 and shown in graphic form in Figure 5. Instructors had rated the relative difficulty of these tasks in order from low to high as chalk test, door dogs, strainer; the elapsed times parallel difficulty predictions. In every case, students who had completed traditional hands-on laboratories took less time to perform the test than those who had only viewed videotaped demonstrations. Statistical analysis results are summarized in Table 4. A 2-way analysis of variance was conducted using task (chalk test, door dogs, or strainer) and group (laboratory or video aid) as independent variables and elapsed time as the dependent variable. As shown in Table 4, task was statistically significant ($F(2,55)=25.75$, $p < .01$). The difference between laboratory and video aid groups was statistically significant ($F(1,55)=4.62$, $p < .05$). The interaction between task and group was not statistically significant. Note that the 2-way analysis aggregated all tasks together. Separate 1-way analyses of variance were conducted for each of the tasks, using group as the independent variable. None of the analyses yielded statistically significant results.

Table 3

Performance Test Speed Data in Seconds as a Function of Group (Laboratory or Video Aid) and Task (Chalk Test, Door Dogs, or Strainer)

	Speed by Task					
	Chalk Test		Door Dogs		Marine Strainer	
Group	Mean	SD	Mean	SD	Mean	SD
Laboratory	563	162	755	196	1007	281
Video Aid	686	148	816	277	1201	223

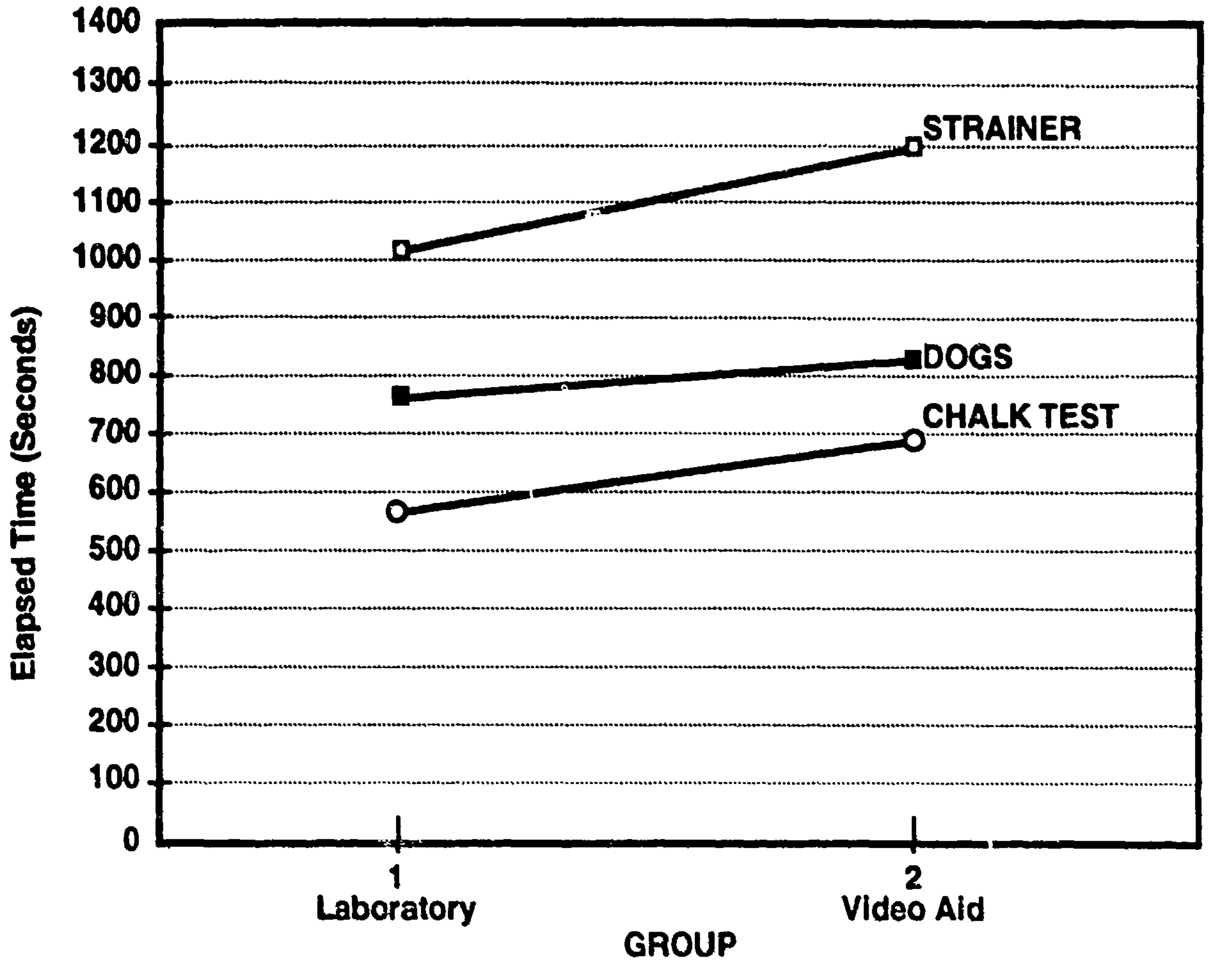

Figure 5. **Performance test speed as a function of group (laboratory or video aid) and task (chalk test, door dogs, or strainer).**

Table 4

ANOVA Results for Performance Test Speed Data

Type of Analysis	Variable	df	F	p
2-way	Task	2,55	25.75	<.01
2-way	Group	1,55	4.62	<.05
2-way	Group x Task Interaction	2,55	<1	NS
1-way	Chalk Test	1,21	3.52	NS
1-way	Door Dogs	1,15	<1	NS
1-way	Strainer	1,19	3.04	NS

Performance test accuracy data are given in Table 5 and shown in graphic form in Figure 6. Two aspects of these results are noteworthy and both relate to the door dogs task. First, the data show that task order in terms of error proneness, from low to high, is chalk test, strainer, door dogs. This is a departure from the order predicted by instructors based on task difficulty estimates (chalk test, door dogs, strainer). Second, we would expect the laboratory group to perform better than the video aid group since only the former had hands-on experience with the tasks covered in the performance tests. Neither prediction is correct. Statistical analysis results are summarized in Table 6. A 2-way analysis of variance was conducted using task (chalk test, door dogs, or strainer) and group (laboratory or video aid) as independent variables and number of errors as the dependent variable. Task was statistically significant ($F(2,56)=18.94$, $p < .01$). The difference between laboratory and video aid groups was not statistically significant.

Table 5

Performance Test Accuracy Data as a Function of Group (Laboratory or Video Aid) and Task (Chalk Test, Door Dogs, or Strainer)

	Accuracy by Task					
	Chalk Test		Door Dogs		Marine Strainer	
Group	Mean	SD	Mean	SD	Mean	SD
Laboratory	0.44	0.73	5.29	1.38	1.46	1.97
Video Aid	1.64	1.69	3.24	2.05	2.00	1.63

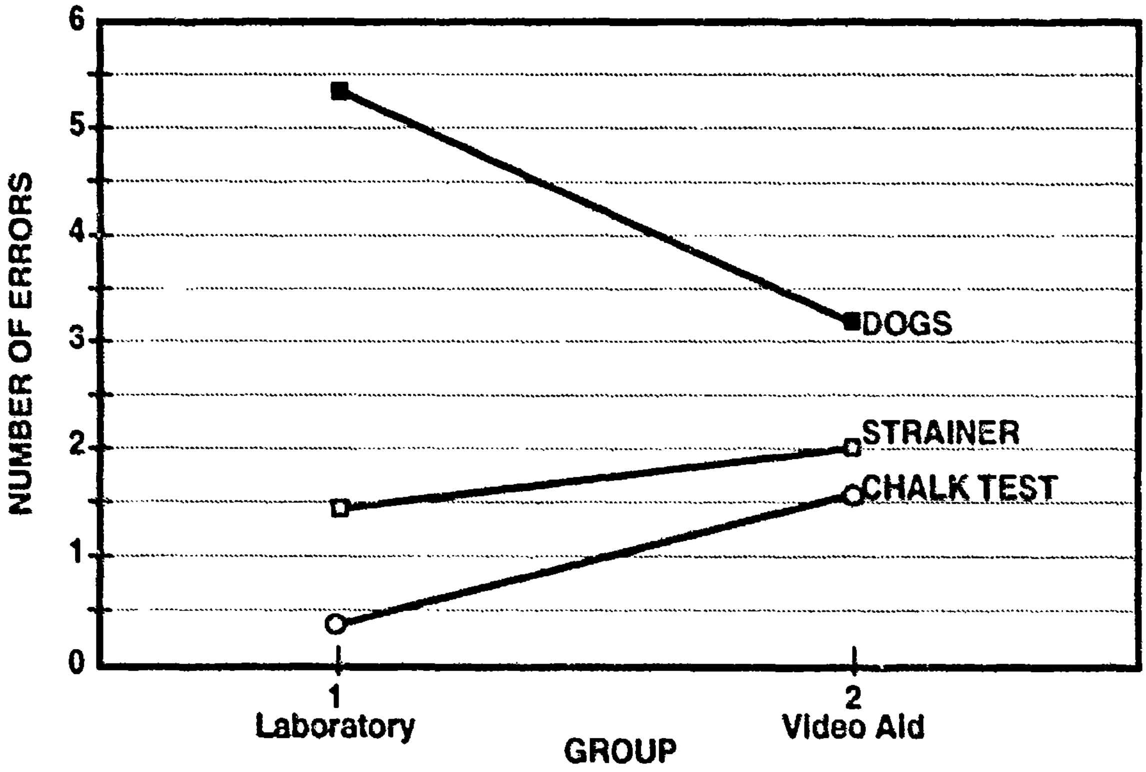

Figure 6. Performance test accuracy as a function of group (laboratory or video aid) and task (chalk test, door dogs, or strainer).

Table 6

ANOVA Results for Performance Test Accuracy Data

Type of Analysis	Variable	df	F	p
2-way	Task	2,56	18.94	<.01
2-way	Group	1,56	<1	NS
2-way	Group x Task Interaction	2,56	4.86	<.05
1-way	Chalk Test	1,21	3.99	NS
1-way	Door Dogs	1,16	5.37	<.05
1-way	Strainer	1,19	<1	NS

There was a statistically significant interaction between task and group ($F(2,56)=4.86$, $p < .01$). Group had a different effect depending on task; that is, the laboratory group did not perform as well as the video aid group on two tasks (strainer, chalk test), but performed better on the remaining task (door dogs) (Figure 6). The contrasting performance profiles explain the interaction. Again, it is the door dogs task that underlies the effect. An explanation is needed to explain the door dogs performance profile (see below).

Separate 1-way analyses of variance were conducted for each of the tasks, using group as the independent variable. The only analysis yielding statistically significant results was for the door dogs task ($F(1,16)=5.37$, $p < .05$).

What explanations can be offered for the surprising results obtained with the door dogs task? After obtaining these results, we discussed these tasks with the instructors and noted the following:

1. Strainer and door dogs tasks have approximately the same number of steps.

2. Chalk test has approximately half as many steps as strainer/door dogs tasks. It is inherently a simpler task than the other two.

3. Disassembly/assembly of the strainer is similar to solving a 3-dimensional puzzle. Once it is disassembled, there is only one correct way to reassemble it. Common errors are to omit non-assembly steps (e.g., lubrication); there are four steps of this type.

4. Disassembly/assembly of the door dogs can be done incorrectly and requires some finesse. Unlike the strainer, it can be reassembled incorrectly (e.g., by installing string packing incorrectly). Additionally, the door dogs task also has many more non-assembly steps than the strainer (total of 9).

What is intriguing about the door dogs test results is that students in the video aid group performed better than those in the laboratory group. Recall that students in the video aid group were tested after they had viewed a videotape demonstrating the task but before they participated in a hands-on laboratory. Viewing the videotape helped them overcome not having participated in the laboratory and actually gave them an edge over students in the laboratory group on the door dogs task. The error profiles revealed that members of the laboratory group were more likely to omit non-assembly steps than members of the video aid group. Assembly steps provide some feedback to students on performance accuracy (e.g., if the part fits, it is reasonable to assume that it has been assembled correctly). However, non-assembly steps such as lubrication do not provide such feedback. Hence, one possible rationale for the effect the videotapes had with the door dogs task is that it was more effective than live demonstrations in helping students learn non-assembly steps.

DISCUSSION AND CONCLUSIONS

The primary objective of the research was to test the feasibility of using VTT to deliver hands-on training. Was feasibility demonstrated? The answer is, yes and no. Some aspects of the experiment succeeded and some did not. In addition, there is much about hands-on VTT that remains unknown.

VTT was effective for lecture, discussion, and hands-on demonstration portions of training as indicated by the final examination, student course evaluations, and observations. The demonstrations were more elaborate and demanding of both instructor and students than those given in lecture-based courses so this success is significant.

VTT classroom design (Figure 1) was effective for hands-on training. This design was adapted from the design used for lecture-based VTT by providing additional storage space, moving back the first row of students to provide a demonstration area, simplifying the instructor's workstation, and providing the instructor with a cordless microphone. The design may serve as a model for use by others designing VTT classrooms for hands-on training.

As noted in the Method section, the most difficult aspect of hands-on VTT is the laboratory, during which the instructor typically works closely with students to demonstrate procedures, supervise, assure safety, and certify student performance. Four different strategies for handling laboratories were mentioned: (1) elimination of laboratory, (2) instructor remote presence, (3) facilitator-conducted laboratory, and (4) conducting training on the job instead of in formal training. The research investigated two of these strategies (1, 3). A modified version of strategy 1 (no laboratory, but videotape) was less than successful. Students who observed videotapes instead of participating in a laboratory took longer to perform on all performance test tasks and performed less accurately on two out of three tasks. Viewing a videotape is no substitute for participating in a laboratory, though it is probably better than no laboratory at all.

The second strategy (remote laboratory) appeared to be more successful, though no performance data were collected to verify this to be the case. Our observations indicated that the learning processes occurring in remote laboratories were very similar to those of a live class, and relied heavily on student prior knowledge and peer training. The laboratories might not have been as successful if students were performing laboratory tasks for the first time. Additional research is required to determine whether or not this strategy would be generally effective.

The research provided some evidence that videotapes are more effective than live demonstrations in helping students learn to perform procedural steps that do not in themselves provide feedback on their correctness (e.g., the non-assembly steps of the door dogs task). This finding is suggestive and warrants further investigation on a broader range of tasks than were investigated in this study. Note that it has implications not only for VTT but for any training involving demonstrations.

In converting hands-on courses for VTT, students must be provided with hands-on training in some form. The two most realistic strategies at present appear to be strategies 3 or 4. Additional research should be conducted to refine the laboratory strategies used, to apply them to other types of training (e.g., electronics troubleshooting, fiber optics maintenance, etc.), and to determine if other strategies can also be effective (e.g., strategy 4).

RECOMMENDATIONS

1. The Chief of Naval Education and Training should ensure that VTT classrooms used to originate courses with a significant hands-on training component are designed to satisfy the special requirements of these courses. Among the requirements are additional storage space for training aids, an open and flexible floor plan, a demonstration area covered by a separate camera, an instructor's workstation, and a cordless microphone to provide the instructor with mobility.

2. The Chief of Naval Education and Training should employ the most practical and effective strategy known at this time for conducting hands-on laboratories at remote sites: equip remote sites with laboratory equipment and have a facilitator conduct the laboratories off line. While this laboratory strategy is workable, other less costly strategies should be investigated further.

3. The Chief of Naval Education and Training should originate a Problem Description and Need Justification for research to test and evaluate alternative strategies for conducting VTT hands-on laboratories. Among these strategies are remote presence, the use of on-board training packages to allow supervisors to train students on the job, and other strategies that may be feasible and effective.

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APPENDIX A

STUDENT BACKGROUND QUESTIONNAIRE

STUDENT SURVEY
DAMAGE CONTROL PETTY OFFICER
J-495-0400

Date:____________________ Rate____________________ Room No.________

Name______________________________________ SSN(OPT)________________

PLEASE CIRCLE THE LETTER FOR THE MOST APPROPRIATE ANSWER

1. Did you request this course of instruction?

   A. Yes B. No

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

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

3. Have you had any previous Damage Control experience?

   A. Yes B. No

4. What is your current DCPO PQS qualification level?

   a. Maintenance Person
   b. Work Center Supervisor
   c. Division Officer
   d. Departmental Assistant
   e. Department Head
   f. DC Petty Officer
   g. None

5. What is your current assignment?

   a. Maintenance Person
   b. Work Center Supervisor
   c Division Officer
   d. Department Head
   e. DCPO
   f. Departmental DC Assistant

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

   a. Maintenance Person
   b. Work Center Supervisor
   c Division Officer
   d. Department Head
   e. DCPO
   f. Departmental DC Assistant

FOR OFFICE USE ONLY

FINAL GRADE____________________

APPENDIX B

PERFORMANCE TESTING PROCEDURE, SCORING RULES, STUDENT INSTRUCTIONS, AND PERFORMANCE TESTS

PERFORMANCE TESTING PROCEDURE

Materials

1. PMS card
2. Equipment

Preparation

Before testing, prepare equipment by assembling or returning it to pre-test condition.

Testing Procedure

1. When student enters testing area, introduce yourself and read "Student Instructions."
2. Start stopwatch.
3. Observe student and score performance on protocol.
4. If the time limit for the test has passed, terminate test. Otherwise, when student indicates he/she is finished, stop stopwatch.
5. Record elapsed time on protocol.
6. Caution student not to discuss test with other students.
7. Excuse student.

PERFORMANCE TEST SCORING RULES

Completeness

Put check mark by task step if student performs it; otherwise leave blank.

Errors

An error is an attempt to perform a step in an incorrect manner. Examples:

1. Not performing the task to its required standard (e.g., miscalibration).
2. Performing a task out of sequence (scored as error if it must be redone to perform subsequent steps properly); ignore sequence if it has no subsequent effect.
3. Attempting to assemble a part improperly (e.g., in reverse of its correct orientation).
4. Failing to perform a step completely (e.g., neglecting to grease a part [ignore if this would be captured by "completeness" score]).
5. Leaving out a part or attempting to install an inappropriate part.

Elapsed Time

The amount of time from start to end of test. Stop test if elapsed time exceeds 20 minutes.

STUDENT INSTRUCTIONS

Door Dogs

(Read to student before starting test)

You will be taking a performance test. This test is designed to find out how accurately and quickly you can perform the PMS procedures for the Watertight Door Dogs.

This test will not affect your grade in the course. However, it is important for you to do your best on the test because the results will affect how training is administered to other Navy personnel in the future.

Perform the task as accurately and quickly as possible. I will time how long it takes you and will record your errors. The maximum amount of time allowed for the test is 20 minutes.

The DCPO has told you to check the Watertight door dogs for binding and to disassemble, clean, inspect and re-assemble the dogs according to correct procedures.

I cannot talk to you, answer questions, or provide you with help during the test. Do you have any questions before you start? (Answer any non-technical questions.)

Are you ready to begin? (Start test when student indicates readiness.)

STUDENT INSTRUCTIONS

Watertight Door Chalk Test

(Read to student before starting test)

You will be taking a performance test. This test is designed to find out how accurately and quickly you can perform the PMS procedures for the watertight door chalk test.

This test will not affect your grade in the course. However, it is important for you to do your best on the test because the results will affect how training is administered to other Navy personnel in the future.

Perform the task as accurately and quickly as possible. I will time how long it takes you and will record your errors. The maximum amount of time allowed for the test is 20 minutes.

The DCPO has told you to perform the watertight door chalk test.

I cannot talk to you, answer questions, or provide you with help during the test. Do you have any questions before you start? (Answer any non-technical questions.)

Are you ready to begin? (Start test when student indicates readiness.)

STUDENT INSTRUCTIONS

Marine Strainer

(Read to student before starting test)

You will be taking a performance test. This test is designed to find out how accurately and quickly you can perform the PMS procedures for the Marine Strainer.

This test will not affect your grade in the course. However, it is important for you to do your best on the test because the results will affect how training is administered to other Navy personnel in the future.

Perform the task as accurately and quickly as possible. I will time how long it takes you and will record your errors. The maximum amount of time allowed for the test is 30 minutes.

The DCPO has told you to disassemble, clean, inspect, and re-assemble the Marine Strainer and Ball Valve assembly.

I cannot talk to you, answer questions, or provide you with help during the test. Do you have any questions before you start? (Answer any non-technical questions.)

Are you ready to begin? (Start test when student indicates readiness.)

DC PETTY OFFICER PERFORMANCE TEST

WATERTIGHT DOOR CHALK TEST

Trainees name:________________________Rate:____________
Time to complete:__________________minutes:seconds
Did trainee follow MRC card?   Yes____ No____

Completed √	Errors √ √ √	Steps
		Clean gasket & apply chalk to knife edge
		Close & dog watertight door
		Open door & inspect chalk line on door gasket
		Adjust Affected dogs
		Clean gasket & chalk knife edge
		Close & dog door
		Open door & inspect chalk line on gasket
		If line is complete, clean gasket, else return and readjust dogs
		Lubricate gasket with light coat of silicone
		Dog watertight door and inspect for tightness

DC PETTY OFFICER PERFORMANCE TEST

MARINE STRAINER

Trainees name:________________________Rate:____________
Time to complete:__________________minutes:seconds
Did trainee follow MRC card?   Yes____ No____

Completed √	Errors √ √ √	Steps
		Remove eight bolt flange
		Remove and inspect gasket
		Remove and inspect ball
		Remove quick acting flush valve handle
		Loosen six bolt flange to bell body and break seal
		Remove handle locking clip plate
		Remove bell body
		Remove and inspect strainer
		Inspect studs for clean threads
		Remove bearing race access screw
		Apply 3 drops of light oil in slot and replace screw
		Inspect hose gasket at coupling connection
		Reinstall strainer
		Reinstall six bolt flange gasket
		Align and reinstall bell body
		Reinstall handle locking clip plate
		Reinstall all nuts and tighten
		Reinstall T-shaft from strainer handle to ball valve
		Reinstall quick acting flush valve handle
		Reinstall ball valve
		Reinstall eight flange gasket
		Reinstall eight flange and nuts
		Check for smooth operation

DC PETTY OFFICER PERFORMANCE TEST

W'.TERTIGHT DOOR DOGS

Trainees name:_________________________Rate:____________
Time to complete:__________________minutes:seconds
Did trainee follow MRC card?   Yes____ No____

COMPLETED √	ERRORS √ √ √	STEPS
		Remove plunger
		Remove locking & adjusting nut
		Remove dog handle
		Remove spindle assembly from door frame
		Remove spring & string packing from spindle
		Remove inner bushing from spindle
		Remove flange bushing from door frame
		Clean housing in door frame
		Remove packing & clean spindle
		Clean the flange bushing, inner bushing, & spring
		Apply light coat of grease to spindle
		Apply light coat of grease to door housing
		Apply light coat of grease to bushing
		Apply light coat of grease to flange bushing
		Reinstall inner bushing on spindle
		Reinstall spring on spindle
		Install new string packing on spindle
		Reinstall flange bushing & set screw
		Resinstall spindle assembly inside dog handle
		Reinstall adjusting & locking nuts
		Cycle dog handle for smooth operation
		Apply grease stick packing
		Insert set screw & tighten plunger
		Cycle dog handle for smooth operation

APPENDIX C

COURSE QUESTIONNAIRE FOR VTT STUDENTS

Course Questionnaire for VTT Students

1. Name ______________ ______ ______________ ______
First M Last Rate

2. Today's date ____ /____ /____

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

Section 1: Course Evaluation

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

Instructor	Unsatisfactory → Outstanding (Average = 3)				
1. Instructor was prepared for class	1☐	2☐	3☐	4☐	5☐
2. Instructor presented lessons clearly	1☐	2☐	3☐	4☐	5☐
3. Instructor answered student questions	1☐	2☐	3☐	4☐	5☐
4. Instructor encouraged class participation	1☐	2☐	3☐	4☐	5☐
Audio-Visual Aids					
5. Image on video screen was large enough to be seen	1☐	2☐	3☐	4☐	5☐
6. Image on video screen was clear enough to be seen	1☐	2☐	3☐	4☐	5☐
7. Audio from other class was loud enough to understand	1☐	2☐	3☐	4☐	5☐
8. Audio from the other class was clear enough to understand	1☐	2☐	3☐	4☐	5☐
Tests/Homework					
9. Test questions were clearly written	1☐	2☐	3☐	4☐	5☐
10. Test questions were directly related to course	1☐	2☐	3☐	4☐	5☐
11. Test answers were graded fairly	1☐	2☐	3☐	4☐	5☐
Training Aids					
12. Training aids were valuable in supporting instruction	1☐	2☐	3☐	4☐	5☐
13. Training aids were used effectively	1☐	2☐	3☐	4☐	5☐
14. Details of training aids could be seen clearly	1☐	2☐	3☐	4☐	5☐
Labs					
15. Labs helped me understand the course material	1☐	2☐	3☐	4☐	5☐
16. Labs helped me learn to perform the tasks they covered	1☐	2☐	3☐	4☐	5☐
17. There were enough labs to cover the key topics in the course	1☐	2☐	3☐	4☐	5☐
18. The job performance sheets were effective in describing task steps to perform during the labs	1☐	2☐	3☐	4☐	5☐
19. The instructor of ficalitor provided enough help during the labs	1☐	2☐	3☐	4☐	5☐
20. The videotapes running during the labs were valuable	1☐	2☐	3☐	4☐	5☐
Overall					
21. Comparison of this instructor to other Navy instructors that have taught you in the past	1☐	2☐	3☐	4☐	5☐
22. Comparison of this course to other Navy courses that you have taken in the past	1☐	2☐	3☐	4☐	5☐

Section 2: Instructor-Student Interaction

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

- ☐ *a. Yes*
- ☐ *b. No*

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

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

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

- ☐ *a. Video tele-training*
- ☐ *b. Live instruction with instructor physically present in the classroom*
- ☐ *c. No preference between video tele-training and live instruction*

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

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

Section 3: Student Comments

27. What did you like most about this course?

____

____

____

____

____

____

____

28. What did you like least about this course?

____

____

____

____

____

____

____

Section 3: Student Comments (continued)

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

30. Comment on usefulness and adequacy of the course content:

31. Comment on instructor preparedness and presentation:

32. Comment on adequacy of training aids:

33. Comment on appropriateness of the exams:

Section 4: Safety

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

☐ *Yes* ☐ *No* ☐ *See Remarks*

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

☐ *Yes* ☐ *No* ☐ *See Remarks*

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

☐ *Yes* ☐ *No* ☐ *See Remarks*

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

☐ *Yes* ☐ *No* ☐ *See Remarks*

Comment on safety:

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