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This report describes research conducted by the UCLA National Center for Research on Evaluation, Standards, and Student Testing (CRESST) and its subcontractor, the University of Southern California Behavioral Technology Laboratories (BTL), on the integration of assessment models and tools with instructional simulation authoring and delivery tools designed to support Naval distance learning (DL) with application to Marine Corps marksmanship training. The assessment models and tools provide precision measurement, analysis, and diagnosis of learner performance guiding selection and delivery of remedial training through the instructional simulations. A second subcontractor, CHI Systems, Inc., conducted field-based qualitative research on Navy and Marine Corps DL implementations to develop practical guidelines and procedures to support effective DL employment in the Navy and Marine Corps.

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Interim Report:
Research on USMC Marksmanship Training Assessment Tools, Instructional Simulations, and Qualitative Field-Based Research

January 10, 2003

Knowledge, Models and Tools to
Improve the Effectiveness of
Naval Distance Learning

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Office of Naval Research
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INTERIM REPORT: RESEARCH ON USMC MARKSMANSHIP TRAINING ASSESSMENT TOOLS, INSTRUCTIONAL SIMULATIONS, AND QUALITATIVE FIELD-BASED RESEARCH

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Executive Summary

The Office of Naval Research (ONR) has funded the UCLA National Center for Research on Evaluation, Standards, and Student Testing (CRESST) and its subcontractor, the University of Southern California Behavioral Technology Laboratories (BTL), to conduct research on the integration of assessment models and tools with instructional simulation authoring and delivery tools designed to support Navy and Marine Corps distance learning (DL). An assessment model is a formal specification of tasks and measures producing data that can be used as evidence to support inferences about what the learner knows. For this project the assessment models and tools provide precision measurement, analysis, and diagnosis of learner performance guiding selection and delivery of remedial training through the instructional simulations. ONR is also funding CHI Systems, Inc. to conduct field-based qualitative research on Navy and Marine Corps DL implementations to develop practical guidelines and procedures to support effective DL employment in the Navy and Marine Corps.

The initial focus of these research efforts was USMC marksmanship training at the Camp Lejeune Weapons Training Battalion. CHI Systems, Inc. conducted a qualitative field-study-based approach to assess the effectiveness of existing DL while the CRESST/BTL effort used the marksmanship training context to explore new options for DL assessment and training. Following intensive knowledge acquisition to build an appropriate marksmanship knowledge base to guide assessment development and scoring, CRESST created and pilot tested several DL-delivered assessment tools including knowledge mapping, a prior knowledge questionnaire, shot group depiction, a background survey, a self-regulation survey, and an assessment of rifle marksmanship measuring Marines' skill at identifying proper and improper firing positions. Data are still being analyzed, but preliminary results indicate that such cognitive measures in combination with background information can indeed predict shooter performance and do it as well as or better than far more expensive and time-consuming measures. CRESST's data recently collected at Camp Lejeune's Stone Bay Rifle Range indicate that a combination of background variables and cognitive measures predict qualification scores with a multiple regression coefficient of .59. Benchmarks for comparison are the best results obtained using performance on a rifle simulator (Hagman, 1998), which show a correlation of .69, and a Marine's most recent qualification score, which shows a correlation of .40.

To enable use of assessment results in selecting and delivering remedial training, BTL and CRESST have developed and prototyped a way to integrate assessment results and interactive distributed training. Simulations and simulation-centered training modules for marksmanship training were developed using BTL's iRides authoring and delivery systems. iRides and iRides Author, originally developed with ONR support, have continued to be enhanced and extended in the current ONR-sponsored project. Simulation-based training modules have been developed for the Battlesight Zero procedure and shot group analysis. Additional modules on creating the proper sight picture and data book usage are under development.

CHI's field-based, qualitative study of Marine Corps marksmanship training employed extensive interviews with trainers, trainees, and administrators to provide an overall assessment of training quality. CHI found widespread dissatisfaction with current Phase I training, because of the inconsistency with which it appears to be conducted. Existing advanced technology was found to be little used. Extensive

"down time" for the Indoor Simulated Marksmanship Trainer (ISMT) since its introduction has led trainers and trainees to have little confidence in its availability during the brief Phase I training. Problems (whether real or perceived) of skill transfer from the simulator to the real firing range also deterred ISMT usage. In addition, limited number of available computers constrained use of the digitized marksmanship ADL course. The course was also not integrated into the Phase I curriculum in a clear way, leading trainers away from its use.

The combined efforts of CHI, CRESST, and BTL provide an overall picture of the current state of DL in USMC marksmanship training and prototype assessment and instructional simulation tools of potential benefit to USMC marksmanship training through early identification and remediation of Marines likely to shoot poorly. Early identification and remediation could lead to savings in travel cost, time away from the Marine's home unit, the coaches' time on the firing line, the use of firing range capacity, and the cost of ammunition and targets. In addition to savings, early identification and remediation could lead to higher scores overall, fewer UNQs, and more Experts. To realize these potential benefits, the following work should be completed. The first two tasks would require transition funding.

- Validation of the assessments' ability to go beyond prediction of overall shooting performance to identify specific knowledge gaps, predict the impact of the missing knowledge on shooting performance, and identify the remediation required to fill the gap.

- Shrink-wrapping, bullet-proofing, and validating a complete assessment and training package based on the prototypes.

- Qualitative studies of the results of fielding the assessment and training package produced with transition funding, including analyses of how organizational processes adapt (or need to adapt) to make effective use of DL delivery, and guidelines and a supporting case study helping the Navy (via NETC) and Marine Corps (via the DLC) better design and employ DL.

In addition, the following work might be considered for additional R&D funding:

- Integrating assessment and training with the forthcoming Marine LOMAH (Location Of Miss And Hit) system. This may make it possible to assess shooting performance directly and automatically, and to select appropriate training modules based on that performance.

- Hand-held assessment and training modules. These could be used to teach data book activities in the context of real shooting environments, with automatic evaluation and feedback. Advice could be provided on the firing line, and instructors could be automatically alerted about problems. If integrated with the LOMAH system, these hand-held devices could also provide feedback and advice about actual shooting performance.

INTERIM REPORT: RESEARCH ON USMC MARKSMANSHIP TRAINING ASSESSMENT TOOLS, INSTRUCTIONAL SIMULATIONS, AND QUALITATIVE FIELD-BASED RESEARCH

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January 10, 2003

Introduction

The UCLA National Center for Research on Evaluation, Standards, and Student Testing (CRESST) and its subcontractor, the University of Southern California Behavioral Technology Laboratories (BTL), are under contract to the Office of Naval Research (ONR) to conduct research on assessment models and tools integrated with instructional simulation authoring and delivery tools designed to support Navy and Marine Corps distance learning (DL). The project is called Knowledge, Models and Tools to Improve the Effectiveness of Naval Distance Learning, or KMT. CRESST is responsible for assessment models and tools. An assessment model is a formal specification of tasks and measures producing data that can be used as evidence to support inferences about what the learner knows. BTL is responsible for instructional simulation authoring and delivery tools. For this project the assessment models and tools provide precision measurement, analysis, and diagnosis of learner performance guiding selection and delivery of remedial training through the instructional simulations. The approach to conducting KMT research has been to develop and test tools designed to address the assessment and training requirements posed by real Navy and Marine Corps training applications. The first such application is USMC marksmanship training.

ONR has also funded CHI Systems, Inc. to conduct ethnographic research on Navy and Marine Corps DL implementations, the purpose being to document and evaluate the transformation process from traditional to DL training and identify what works, what does not work, causes of problems, and successful solutions to problems in order to develop guidelines for DL implementation. In FY02, CHI was a subcontractor to both CRESST and the Naval Air Systems Command, Training Systems Division (NAVAIR TSD). In FY03, the company's work on DL implementation continues to be funded by ONR, but the contract is managed solely by NAVAIR TSD.

This document provides a summary of work completed to date on the USMC marksmanship application. It begins with an overview of the current marksmanship training process and a description of the concept for using assessment and simulation tools to meet marksmanship training requirements. Knowledge acquisition, assessment development, and pilot testing are then described, followed by an overview of BTL's work in using instructional simulation authoring and delivery tools to develop simulations providing remedial training in marksmanship fundamentals. The document ends with a summary of CHI's work toward developing a baseline description of the existing marksmanship training program, which will enable documentation of transformations that may occur with adoption of a DL approach to marksmanship training, possibly but not necessarily including the KMT assessment tools and instructional simulations.

The Current Marksmanship Training Process

KMT project work on marksmanship training was conducted at the Stone Bay Rifle Range, Camp Lejeune, North Carolina. Stone Bay marksmanship training spans one-and-a-half weeks and is divided into three Phases. Phase I provides the Marines with instruction on the fundamentals of marksmanship. Phase II is actual live firing of the weapon on the Known-Distance (KD) course. Phase III is field firing.

Phase I has two components: classroom instruction and snapping-in. During the classroom instruction, Marines are given a review of the fundamentals of marksmanship. For all Base Marines and some Group Marines, Phase I is conducted at Stone Bay. Marines who do not complete Phase I at Stone Bay conduct it at their individual units with their Primary Marksmanship Instructors (PMI).

Annual qualification at Stone Bay spans the course of a week and a half. Phase I begins on Wednesday of the first week. Marines are given 12-15 hours of classroom instruction over the course of two days. The courses are taught by BMTU (Base Marine Training Unit) for Base Marines and FSSGMTU (Force Service Support Group Marine Training Unit) for the Group Marines. FSSGMTU gives their Marines an entrance survey consisting of five questions regarding their previous annual qualification. For example, Marines are asked to provide their previous shooting score and any perceived difficulties they may have regarding rifle marksmanship. FSSGMTU also gives a Phase I final exam at the end of classroom instruction. The coaches use these tools as one means of assessing Marines who may not have grasped the fundamentals.

Each day after classroom instruction, Marines move to the grass where they spend approximately three hours "snapping-in," which consists of practice getting in and out of positions, sighting in, and running through a mock KD course. One coach is available per 5 to 10 Marines to provide individual assistance.

Marines who complete Phase I at their individual units are required to have classroom instruction and to spend time snapping-in. Upon arriving at Stone Bay, they are required to submit a letter from their unit commander verifying their completion of Phase I prior to beginning Phase II.

On Friday of the first week, all qualifying Marines arrive at Stone Bay for their grouping and battlesight zero exercises. Marines are on deck by 0630 and are done by 1230. Phase II begins on the following Monday. On Monday, no qualification takes place. Marines shoot the KD course with coaches on the firing line assisting the Marines. The coaches' priority is safety, not instruction, and they are not able to provide much individualized attention. The ratio of coaches to Marines is about 1:4. Starting Tuesday, Marines have the option of either attempting qualification or continuing to shoot the KD course for practice. Those who qualify may return to their units, but must return on Friday for Phase III. Marines who attempt to qualify but shoot below a 25 are classified as unqualified and must return on Wednesday for training and attempt qualification on Thursday. On Wednesday, those who did not attempt qualification on Tuesday may attempt qualification. On Thursday, all Marines must attempt qualification or reattempt qualification if they did not qualify on either of the previous two days. Currently, Marines who do not qualify by Thursday are given the option of returning to Stone Bay to repeat the entire process

at a later date, or to reattempt qualification Thursday afternoon after additional training.

Phase III is on Friday of the last week. All Marines return to Stone Bay and engage in field firing. Field firing is the part of annual qualification when combat actions are most closely mirrored. For example, Marines wear bulletproof-type jackets, helmets, and gas masks while shooting. Likewise, the targets move from side to side and multiple targets are presented.

The Concept: Using Assessment to Increase Productivity and Effectiveness

In order to reduce the number of Marines in the Unqualified category (UNQ) and increase the number attaining the Expert rating, Lt. Col. Carl Shelton of the Camp Lejeune Weapons Training Battalion (WTBN) developed a concept called UNQ to Expert, abbreviated as U to E or "U-E," and now known as "Huey." Initially, the idea was that assessment tools and simulations could be used to provide remedial training to Marines *after* they failed to qualify. WTBN and KMT staff soon realized, however, that there was much greater potential for time and cost savings if online assessments administered *before* Marines reached the firing line—and even better, before they reached Camp Lejeune—could identify Marines likely to shoot poorly and identify specific needs for remedial training that could be met by online instructional simulation, the Indoor Simulated Markmanship Trainer (ISMT), and/or the Marine Corps Institute (MCI) Rifle Marksmanship online course.

The potential for time and cost savings is there: Early identification and remediation could lead to savings in travel cost, time away from the Marine's home unit, the coaches' time on the firing line, the use of firing range capacity, and the cost of ammunition and targets. In addition to savings, early identification and remediation could lead to higher scores overall, fewer UNQs, and more Experts. But the potential for savings and enhanced shooting performance depends on the ability to identify likely poor shooters and their needs for remedial training using online assessments. Shooting is obviously primarily a motor skill, and it is difficult if not impossible to assess a motor skill in a DL environment. It is possible, however, to assess knowledge—facts, concepts, and their relationships—in a DL environment. If it could be shown that online assessments of knowledge could predict shooting performance and identify the knowledge gap driving the prediction, then Huey could work.

Knowledge Acquisition, Assessment Development, and Pilot Testing

Assessment development must be based on a solid understanding of the domain to be assessed. CRESST researchers visited the Stone Bay Rifle Range at Camp Lejeune five times between April and December of 2002 to acquire such knowledge, which included the collection of rifle marksmanship concepts and fundamentals through an intensive review of marksmanship manuals and training materials (see references USMC, 1992; USMC, 1999; and USMC, 2001). CRESST also conducted extensive interviews with WTBN staff regarding how best to assess the cognitive aspect of shooting to predict shooting performance.

Early in knowledge acquisition it became clear that high-performing marksmen know much more about the fundamentals of rifle marksmanship than poor or average marksmen and use this knowledge to improve their shooting. High-performing marksmen know the fundamentals, the relationships among fundamentals, the effects of fundamentals on shooting performance, how to recognize problems in applying fundamentals, and how to fix problems in applying fundamentals. They use their data books as diagnostic tools. They use shot patterns and the discrepancy between the called shot location and the actual shot location to identify and correct problems in applying fundamentals such as breath control, trigger control, and sight adjustment compensation. Better shooters are able to describe the relationships of elements of shooting positions. For example, they know that the grip of the firing hand affects trigger control, and that stock weld placement affects eye relief.

The knowledge acquired from reviews of manuals and training materials was organized into a network of relationships and stored in an online knowledge base. The knowledge base is used to generate and score assessments, and will be used to identify specific remedial training based on knowledge gaps revealed by assessment results. Screens providing views into the knowledge base are shown in the Powerpoint file stored on the CD delivered at the December 19, 2002, CRESST/BTL briefing in Quantico.

The marksmanship knowledge base defines what *can be known* about marksmanship: marksmanship fundamentals, the relationships among fundamentals, the effects of fundamentals on shooting performance, how to recognize problems in applying fundamentals, and how to fix problems in applying fundamentals. The purpose of assessment in the Marine marksmanship application

is to determine what *is known* by an individual Marine in order to identify Marines who may shoot poorly and identify specific needs for remedial training.

Assessments are designed to elicit learner behaviors, producing data that can be used as evidence to support inferences about what the learner knows (Pellegrino, Chudowsky, and Glaser, 2001). Data may include marks on answer sheets, graphic representations or "concept maps" showing relationships among fundamentals and relationships of fundamentals to shot placement, or a response to a problem posed by an online simulation. To be used as evidence, it must be possible to interpret the data in terms of their relevance to what the Marine knows (and does not know) that is important to shooting performance. This requires that assessment tasks be designed that will provide data that can be linked to the cognitive model to support inferences about the Marine's knowledge of marksmanship fundamentals, the relationship among fundamentals, the effect of fundamentals on shooting performance, how to recognize problems in applying fundamentals, and how to fix problems in applying fundamentals. But it is not enough to simply design assessment tasks. The assessments must also be validated by using them to collect data and determining whether the data can be used to predict shooting performance as indicated by the knowledge base.

A focus on the cognitive aspects of rifle marksmanship is unusual in research on largely psychomotor skills. Prior research on other sports recognizes the existence of cognitive aspects as well as motor skills (McPherson & French, 1991; Thomas, French, & Humphries, 1986). Most marksmanship research has ignored the cognitive dimension, focusing on using scores from rifle simulators to predict qualification scores (e.g., Evans, Dyer, & Hagman, 2000; Hagman, 1998; Schendel, Heller, Finley, & Hawley, 1985; Smith & Hagman, 2000; Torre, Maxey, & Piper, 1987), as well as examining the relationship between background variables and shooting performance (e.g., Carey, 1990). In general, correlations between device-fire scores (from rifle simulators) and record-fire scores range from .40 to .70, which we considered the benchmarks for our research.

To gather information about the quality of assessments, CRESST conducted two pilot studies and one main study. The purpose of the first pilot study was to gather preliminary data on the relationships between knowledge of rifle marksmanship and shooting performance. The purpose of the second pilot study was to test the online versions of our software in the target environment. We wanted to identify, prior to the main study, any technical issues as well as gather

information on the usability of our assessments. The main study was the test of our assessments in the target mode of delivery (online) using as controlled procedures as feasible.

Study A—Pilot Test of Measures (June 2002)

During this pilot test we interviewed the coaches and command staff at Stone Bay to gather responses on our measures, correlated scores on our measures with live-fire scores, and examined the strength of the relationship. We gathered input from the Stone Bay command staff and coaches, practiced firing an M16A2, interviewed coaches, and observed firing procedures.

Measures. The following measures were administered to approximately 60 Marines:

1. Knowledge map. Knowledge mapping was intended to measure in general a Marine's knowledge of rifle marksmanship and in particular, cause-effect relations among different aspects of marksmanship. The task required Marines to graphically depict their understanding of rifle marksmanship in terms of a network. The nodes in the network represented concepts, and labeled links between nodes represented the relationships between concepts. The sets of concept and link labels were provided to Marines.
2. Prior knowledge. The intent of the prior knowledge task was to survey Marines' knowledge of rifle marksmanship. Marines were given 20 terms and asked to provide a short written response that could define the term or explain the significance of the term.
3. Shot-to-shot explanation. The intent of this task was to measure a Marine's reasoning from shot to shot. This measure was an attempt to mimic the cognitive demands of what a Marine would experience on the firing line under slow-fire conditions (i.e., fire a round, observe the strike and evaluate possible causes that could affect the strike). Five frames were shown to the Marine. Each successive frame showed an additional bullet strike. For each frame, the Marine was given a list of 18 possible reasons for the shot pattern. The Marine was required to check off all possible causes that could give rise to the observed shot pattern.
4. Shot group prediction task. The intent of this task was to measure the extent to which a Marine could explain a shot pattern and explain adjustments required to go from one shot group to another shot group.
5. Shot group depiction task. The intent of this task was to measure Marines' knowledge of shot groups associated with common shooter problems. Marines were required to draw a 5-shot group for problems with breathing,

sight adjustment, trigger control, flinching, bucking, and focusing on the target.

6. Background survey. The intent of this task was to be able to characterize the sample and identify background characteristics that could differentiate high- from low-performing shooters. The kind of information gathered included unit information, prior shooting experience and scores, and marksmanship training experience.

Results. Analyses of our preliminary measures suggested a relationship between Marines' self-reported qualification scores and knowledge of marksmanship. Based on this particular sample of Marines, we found that Marines' self-reported qualification score was related to the quality of their knowledge map. Self-reported qualification scores were best predicted by whether the Marine took the coach's course and the frequency of shooting outside of their USMC duties (multiple $R = .62$, $p < .05$), followed by the extent to which they were able to depict shot groups associated with common shooter errors (multiple $R = .55$, $p < .05$). Quality of the knowledge map was also related to qualification scores, although marginally statistically significant ($r = .36$, $p = .08$, $n = 24$). Marines' self-reported *previous* year's qualification score was also related to self-reported qualification score ($r = .38$, $p < .05$).

Limitations. Note that these results were based on a sample of Marines who were administered paper measures under very poor administration conditions. Marines were sitting on bleachers on the firing range, under windy conditions. Also, the measures were exploratory and were our first attempt at measuring knowledge of rifle marksmanship. Thus, these results are at best only suggestive of a relationship between shooting skill and knowledge.

Study B—Pilot Test of Computer Format of Measures (November 2002)

During this pilot test we carried out a technical dry run of our main study and tested the usability of our online assessments with Marines. We dropped measures from Study A that did not appear promising, revised promising measures, and converted the paper measures to an online format. During the administration of our measures, numerous technical issues arose. The most serious issue was the severe security restrictions, which prevented the administration of our QuickTime-based assessments.

Measures. The following measures were administered to approximately 100 Marines:

1. Knowledge map. We refined the knowledge map set of terms and links and developed an online version that Marines could use to draw their maps. We also administered a paper version.
2. Prior knowledge. We converted the prior knowledge measure from a short-answer format to a selected-response format. We developed items for the following areas and adopted several items from a Stone Bay/FSSG-developed test: sight picture, sight adjustment, sight alignment, weapons safety, breathing, trigger control, stock weld, eye relief, bone support, firing hand placement, follow-through, muscle relaxation, forward hand placement, grip of firing hand, and muscular tension.
3. Shot group depiction task.This was like the shot group depiction task used in Study A, except that drawing a shot group for trigger control was dropped.
4. Self-regulation survey. The intent of this task was to measure Marines' use of self-regulation strategies with respect to classroom-based learning (e.g., planning, checking work).
5. Background survey. This was like the background survey used in Study A, with some revised items.

Results. In terms of relationships between our assessments and qualification score, we again found relationships that suggested a link between knowledge of rifle marksmanship and self-reported qualification score. For example, Marines' self-reported qualification score was related to performance on our prior knowledge measure ($r = .21$, $p < .05$); if they rated their job as non-ground combat ($r = .29$, $p < .01$); the number of months since their last Phase I training ($r = -.25$, $p < .05$); and their self-reported most recent qualification score ($r = .36$, $p < .01$).

With respect to performance on our assessments, we found that Marines scored higher on our prior knowledge measure (a) if they had Phase I training ($r = .20$, $p < .05$); (b) the more recently (in months) they had Phase I training ($r = -.24$, $p < .05$); and (c) the higher their self-reported most recent qualification score ($r = .23$, $p < .05$). Also, Marines tended to perform higher on the shot group task (a) if they rated their job as non-ground combat ($r = .21$, $p < .05$); and (b) the more hours they reported shooting as part of their USMC duties ($r = .30$, $p < .05$).

Finally, the best predictor of self-reported qualification scores was from the following set of variables: (a) average of scores on the planning and checking scales

on the self-regulation survey, (b) number of months since the Marine's last Phase I training, (c) score on the prior knowledge measure, (d) self-reported most recent qualification score, and (e) combat status of the Marine's job. The resulting multiple *R* for this sample was .53.

Limitations. As with the first pilot study, the results related to our assessments need to be interpreted with caution. These data are from Marines who took our measures online and on paper. Further, the Marines who received the online assessments experienced technical problems with the software (e.g., slow-loading or non-loading Web pages; very slow system performance).

Given this caution, the results again suggest a knowledge component to shooting performance. As in Study A, self-reported qualification scores were related significantly to measures of knowledge of the fundamentals, although the magnitude of the relationship was low. Evidence that our prior knowledge measure was tapping knowledge of rifle marksmanship is seen in the relationship with the Phase I training variables (i.e., higher scores on the prior knowledge measure if they had Phase I training and the more recent the Phase I training). Finally, the regression equation also supports the interpretation that there is a knowledge component to shooting performance. Prior knowledge scores and recency of Phase I training improves the predictability of shooting performance above experience variables alone.

Study C—Pilot Test of Complete Set of Online Measures (December 2002)

The study conducted in December 2002 was intended to examine the extent to which our online assessments can predict shooting performance. The full set of measures were administered online, and the current and most recent qualification scores were gathered from the Stone Bay database, not Marines' self-reports. CRESST researchers also observed the pit verification process and Stone Bay also provided verifiers to ensure the Marines' bullet strikes were accurately recorded on the score cards. Technical problems with the online delivery were resolved and the online administration during the data collection was problem free. Training on our assessment tasks was standardized to ensure that each Marine had the same training. Further, five CRESST researchers and programmers proctored the data collection.

Measures. The following measures were administered to Marines:

1. Knowledge map. We used the same measure from Study B.
2. Prior knowledge. We used the same measure from Study B with slight modifications to wording.
3. Shot group depiction task. We used the same measure from Study B.
4. Self-regulation survey. We used the same measure from Study B.
5. Background survey. We used the same measure from Study B with slight modifications to wording.
6. Assessment of Rifle Marksmanship Skills (ARMS). This task was intended to measure Marines' skill at identifying proper and improper firing positions. The shooter was shown in QuickTime VR, and Marines could rotate the image to view the shooter from different angles. Marines were asked to judge whether the shooter's position was proper or improper on the following elements: placement of firing hand, placement of forward hand, elbow placement, stock weld, breath control, rifle butt in pocket of shoulder, leg placement, feet placement, body placement, and overall position.
7. Evaluation. A short survey asked Marines how much they knew of rifle marksmanship, their perceived importance of knowledge of marksmanship to shooting performance, and the difficulty of our assessments.

Results. In terms of relationships between our assessments and qualification score, we again found relationships that suggested a link between knowledge of rifle marksmanship and official qualification score. For example, Marines' official qualification score was related to their performance on our prior knowledge measure ($r = .31$, $p < .01$), shot group depiction measure ($r = .18$, $p < .05$), ARMS ($r = .16$, $p < .05$), the number of months since their last Phase I training ($r = -.23$, $p < .01$), the average of scores on the planning and checking scales of the self-regulation survey ($r = .16$, $p < .05$), and their most recent qualification score ($r = .40$, $p < .01$).

With respect to the performance on our assessments, we found that Marines scored higher on our prior knowledge measure (a) if they had Phase I training ($r = .23$, $p < .01$); and (b) the more recently (in months) they had Phase I training ($r = -.34$, $p < .05$). Also, an unexpected negative relationship was found on the shot group depiction task. The higher Marines performed on the shot group task (a) the lower the number of hours they reported spending shooting a rifle as part of their USMC duties ($r = -.16$, $p < .05$); (b) the less frequently they reported shooting a rifle outside their USMC duties ($r = .16$, $p < .05$); and (c) the more recently (in months) they had Phase I training ($r = -.25$, $p < .01$). For the knowledge mapping measure, Marines

who scored higher on the knowledge map (a) reported their jobs as non-ground combat (r = .20, p < .05); (b) had had Phase I training (r = .19, p < .05); (c) reported spending a lower number of hours shooting a rifle as part of their USMC duties (r = -.20, p < .05); and (d) had more recently (in months) had Phase I training (r = -.20, p < .05).

Finally, the best predictor of qualification scores was from the following set of variables: (a) average of scores on the planning and checking scales, (b) number of months since the Marine's last Phase I training, (c) the prior knowledge score, (d) most recent qualification score, (e) if the Marine took the coach's course, (f) shot group depiction score, (g) ARMS score, and (h) number of strong causal links in their knowledge map. The resulting multiple R for this sample was .59 (34% of the variance in qualification scores explained). Using a regression model with only background variables, the multiple R was .49 (24% of the variance explained). Thus, the addition of cognitively based measures explained 10% more variance in the qualification score beyond what was explained by background variables alone. This increase suggests that there is a cognitive component.

Findings

In general, our very preliminary results suggest the following:

1. A cognitive component exists for rifle marksmanship. Evidence for this interpretation was found in the statistically significant relationships between our measures of knowledge and qualification scores, and in the regression equation used to predict qualification scores.
2. The single best predictor of qualification score was a Marine's most recent qualification score (r = .40).
3. The second single best predictor of qualification score was a Marine's score on our prior knowledge measure (r = .31).
4. When we combined background information and knowledge of rifle marksmanship information, our preliminary regression model predicted qualification scores nearly as well as the highest rifle-simulator-based results. The highest correlation was reported by Hagman (1998), with r = .69; our study found multiple R = .59.
5. Using only background variables—most recent qualification score, how long ago the Marine had Phase I training, if the Marine took the coach's course—predicted qualification scores with a multiple R of .49.

6. The inclusion of knowledge-based measures adds substantially to the prediction of qualification scores, above and beyond background variables alone. Including information about Marines' knowledge of rifle marksmanship improved the predictability substantially (multiple R = .59).

Development and Internet Delivery of HUEY Training Prototypes

Researchers at Behavioral Technology Laboratories and CRESST have developed a conception for the integration of assessment and interactive distributed training that is represented in Figure 1.

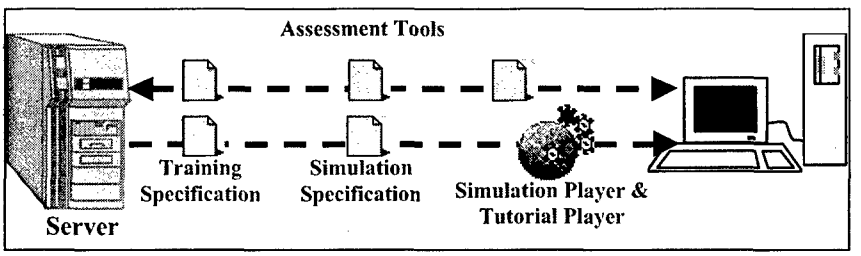

Figure 1. Battlesight Zero lesson for Marine marksmanship.

In this vision, learners run browser client programs that access assessment tools that are delivered by a central server. Based on the detailed assessments, particular training modules are provided to the student. In a typical training sequence, a Marine would first complete certain assessments and would then interact with a training module chosen to address deficits detected by those assessments. Depending on performance during that training, other assessments would then be selected. The results of these, in turn, would determine which subsequent training modules would be delivered to the student. This process would continue either until criterion assessment results were obtained or until available training materials were exhausted. A report of the remediation carried out and any remaining conceptual deficits about marksmanship for that student would then be generated.

One goal of this project is to produce a proof-of-concept prototype that implements the major elements of this vision for integrated assessment and distributed training delivered on the Web.

Training Content Modules in the Prototype

Four major interactive Web-delivered training modules are envisioned. Two of these have been largely completed and two are in development. The completed modules teach the Battlesight Zero (BZO) procedure and shot group analysis. The modules in development will teach about Sight Picture and effective use of the data book.

Battlesight Zero. The BZO module guides the Marine through the process of carrying out the BZO procedure. In the process, it may remediate misconceptions that it encounters during the training process. The purpose of this module is not to teach the sensory and motor skills that can only be learned by actually handling and firing a weapon. Its purpose is to teach the steps of and the reasons for the Battlesight Zero procedure. In this module, students practice creating shot groups and deciding how to adjust the sights based on those shot groups. Finally, they must adjust the sights back to a zero wind condition to complete the BZO process.

Figure 2 shows the beginning of the BZO module, in which the student is introduced to the lesson. It explains how the student aims by placing the sights on the target and that shots are fired by pressing the space bar. In Figure 3, the lesson has noticed that the student attempted to fire a shot while the gun was not even pointed at the target. Students cannot proceed unless they follow the directions.

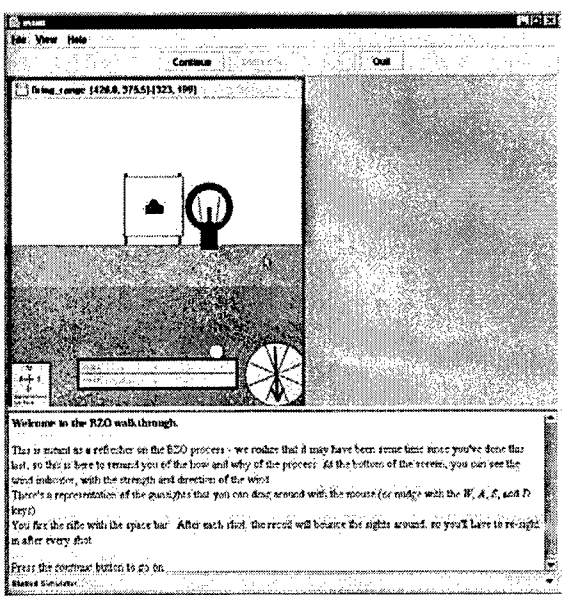

Figure 2. Introduction to Battlesight Zero.

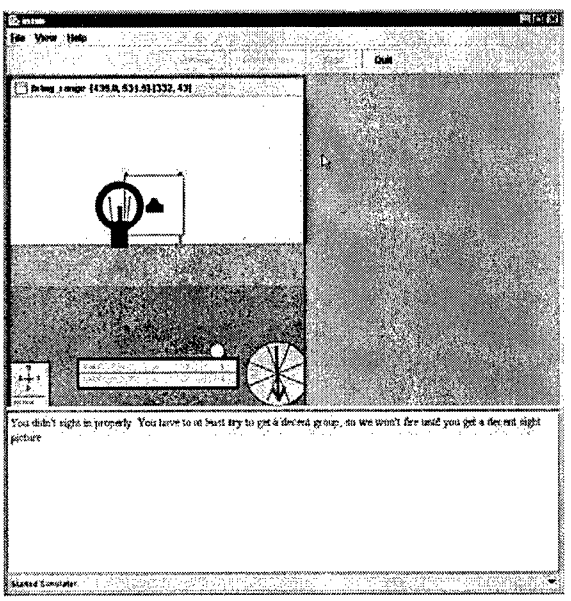

Figure 3. Remediating gross aiming error.

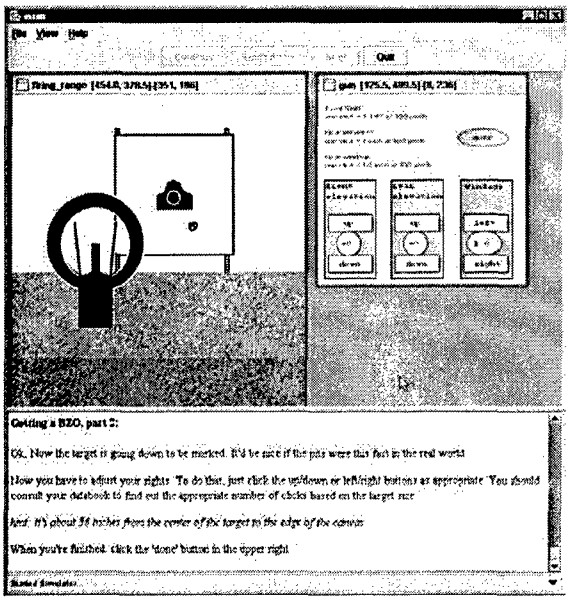

Figure 4. Introduction to sight adjustment.

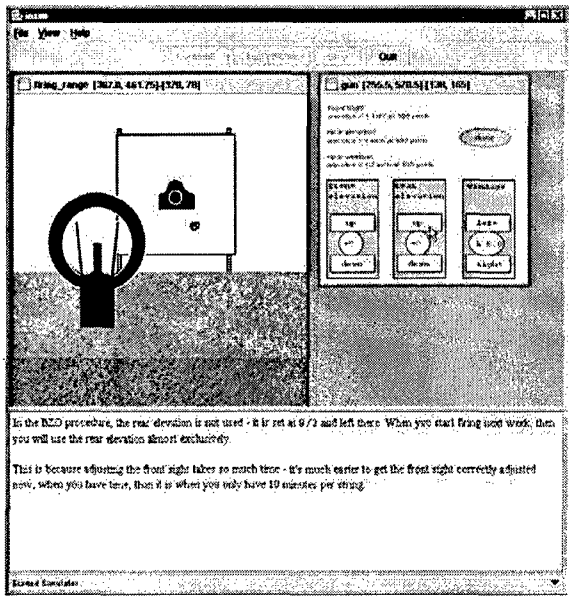

Figure 5. Remediating use of rear elevation adjustment during BZO.

Once a group of shots has been fired, the target is taken down and marked, and is then raised up again. The view then zooms in on the marked target, as shown in Figure 4. The student is instructed on how to adjust the sights and is given an opportunity to do so.

If a student (wrongly) attempts to use the Rear Elevation adjustment, the lesson catches the error and explains that this adjustment is not used in the BZO procedure (Figure 5). When the Marine's sight adjustment is finished, he or she is given feedback on the adjustments, as in Figure 6. The student then fires another group of shots and readjusts the sights. After firing a final group of shots to see the effects of the final adjustments, the student is reminded that this BZO process is an important precondition to being able to qualify (Figure 7).

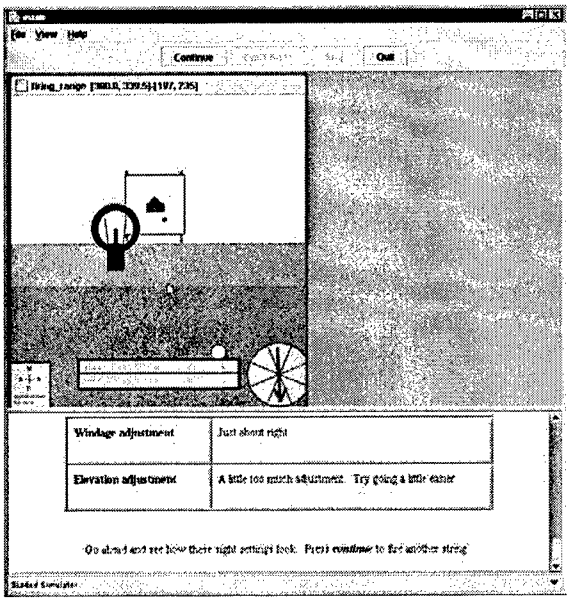

Figure 6. Providing feedback on sight adjustments.

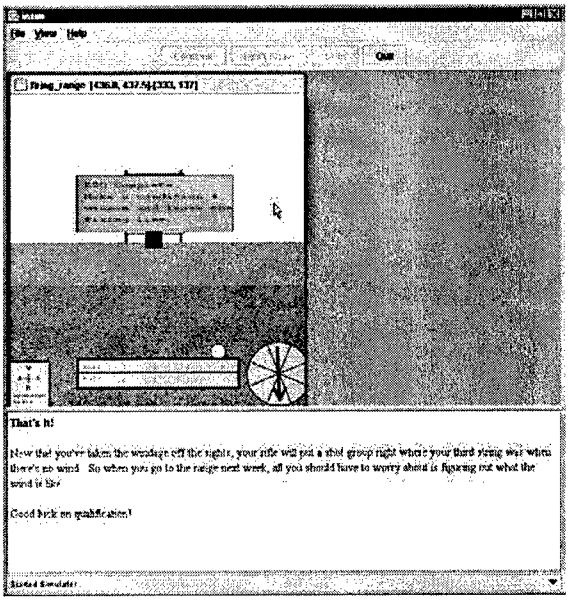

Figure 7. Relating the BZO process to qualification.

Shot group analysis. The shot group analysis training module teaches the Marine to classify four shot group patterns: good groups, trigger control problem groups, breathing problem groups, and groups with complex (or undiagnosable) problems. It would be possible to extend this module to teach the recognition of other shot pattern types, if Marine subject matter experts can agree on other useful characterizations of shot group patterns.

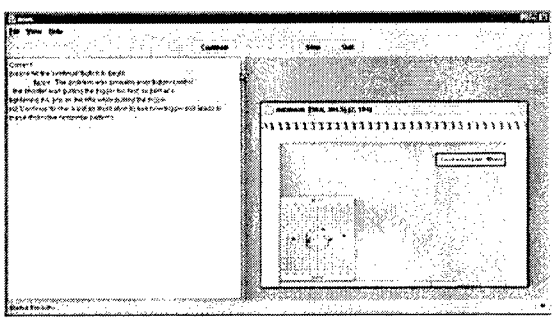

Figure 8. Not recognizing trigger control problem.

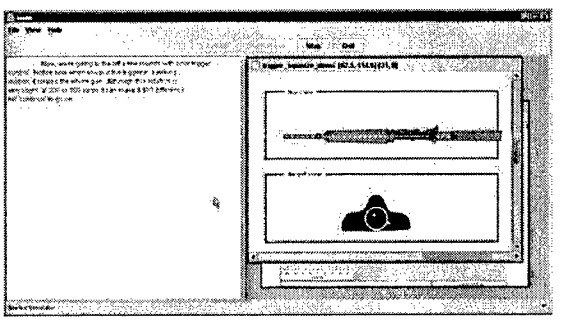

Figure 9. Remediation with visualization.

In Figure 8, a Marine has failed to recognize that a horizontally dispersed shot pattern is a sign of a trigger control problem. In addition to informing the student that that is the depicted problem, it also brings up a visualization, in Figure 9, that

animates the rifle pivoting around the trigger hand while shots appear, one by one, in a horizontally spread-out pattern.

Misconceptions about breath control are also remediated with a visualization in which the breathing of a stick figure soldier (whose torso expands and contracts) causes the rifle to pivot vertically. This is correlated with the vertical movement of the sight over the target (Figure 10).

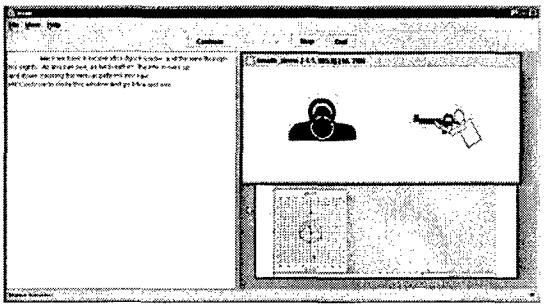

Figure 10. Remediating failure to recognize breath control problem with visualization.

Sight picture module. Marines need to be taught how to create the proper sight picture, by focusing not on the target or on the rear sight, but rather on the front sight. Figure 11 shows a portion of the in-progress module on this topic.

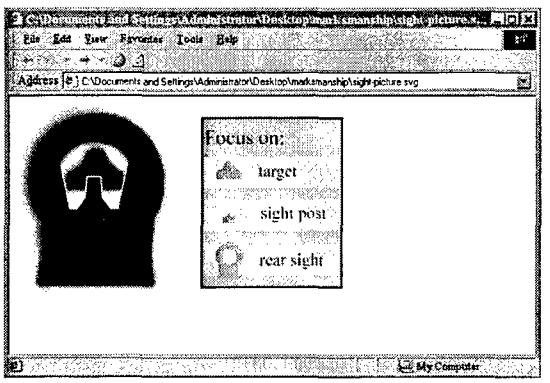

Figure 11. Sight picture simulation (in development).

Data book usage. The fourth module, which is currently being designed, will teach Marines how to use the data book, and will give them evaluated practice in using it to record conditions and shooting performance. CRESST investigators have

found that extensive data book usage is highly correlated with good qualification performance.

Authoring Tools to Promote the Maintainability of ADL Content

Under ONR funding, Behavioral Technology Laboratories is developing new tools to support the development, maintenance, and modification of ADL content.

Chief among these tools is *iRides Author*, an application that supports the development of modifiable simulations and modifiable training control specifications. Figure 12 shows several of the authoring interfaces.

The modifiability of training content means that it will be possible for other contractors or authorized Marine personnel to modify any aspect of the training content. This can include the behavior of simulated systems, the wording of directives or explanations, and the performance criteria for students, along with many other characteristics of the training package. It is expected that this use of authoring tools, rather than low-level programming languages, will make it feasible for the Marine Corps to adapt the content for future requirements.

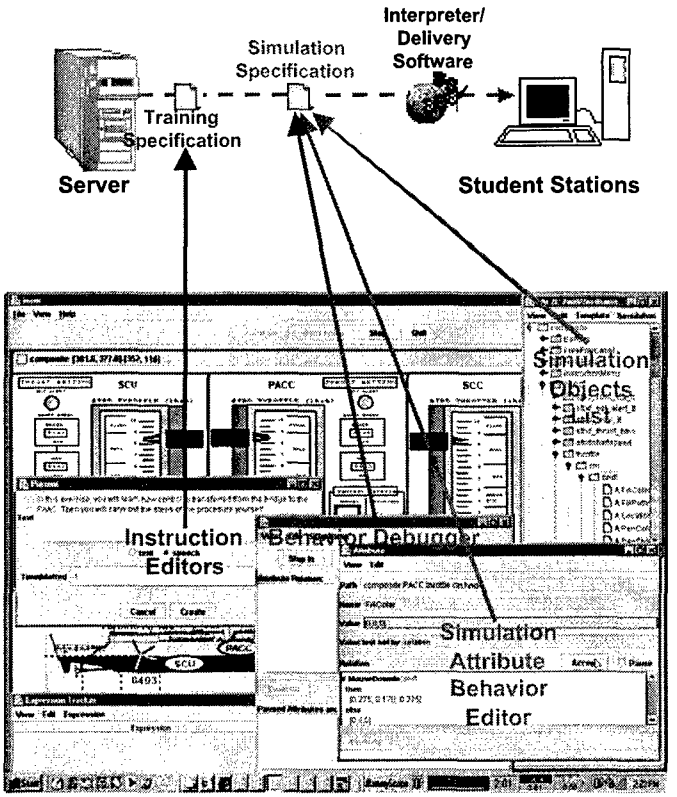

Figure 12. Authoring advanced content.

The Baseline Description of Existing Marksmanship Training

This section summarizes an initial study of Marine Corps training undertaken as part of the Office of Naval Research Capable Manpower Future Naval Capabilities program. The study is part of a larger Capable Manpower program investigating the employment of advanced distributed learning (ADL) technology in the Navy and Marine Corps, with the overall goal of developing practical guidelines and procedures to support effective ADL employment in the future. This larger program is conducting a number of qualitative studies of training curricula as delivered under both traditional (e.g., classroom-based or practice-based) and ADL formats. These studies are providing data on how instructional content is being delivered to Marine Corps and Navy personnel, and on how organizational processes adapt (or need to adapt) to make effective use of ADL-based delivery. Once completed, the data from these studies will provide the basis for guidelines and supporting case studies intended to help the Navy (via NETC) and Marine Corps (via the DLC) better design and employ ADL technology.

Researchers from CHI Systems, Inc. conducted this study in two phases. The first phase involved interviewing rifle training administrators and instructors about existing practices and processes at a specific weapons training battalion. In the second phase, a researcher spent two weeks at the training battalion, directly participating in all aspects of marksmanship training, just as any regular trainee would (and eventually qualifying as an Expert). In addition to the direct observation of and participation in the process from a trainee's perspective, the second phase also involved conducting extensive interviews with many of the participants (trainers and trainees), and documenting their experiences with the existing training program, as well as their attitudes toward and opinions of different ADL training strategies. To anticipate future impediments to ADL employment, trainees and trainers were asked to discuss critical training processes and tasks, and to comment specifically on the role(s) that the advanced technology (e.g., an existing digitized marksmanship course and/or the ISMT device) should play, if any, in a revamped training program. During the observations and interview, explicit attention was paid to noting the subtle (and not-so-subtle) indicators of skepticism, optimism, frustration, enthusiasm, and other important attitudinal variables, which signal the presence or absence of organizational support for particular ADL initiatives.

Findings Relating to Current Marksmanship Training

The findings of the study are summarized below, according to their relevance to Phase I training, Phase II training, or ADL-specific issues.

Phase I. The study found widespread dissatisfaction with Phase I training, reflecting problems with the existing, conventional approach, which brings a large group of trainees together in a classroom for a day or two to listen to lectures covering the mechanics and artistry of shooting the M16A2. A number of factors have combined to undermine the effectiveness of Phase I training at the WTBN. The majority of supervisors at the WTBN cited the absence of centralized command over Phase I as one of the biggest problems—if not *the* biggest—with current marksmanship training. Although unit commanders attest to the fact that their trainees have gone through the full set of lectures prior to arriving at the WTBN for field practice, supervisors at the WTBN strongly suspect that many trainees receive only cursory instruction. Supervisors told accounts of shooters who appeared to be struggling with even the most basic procedures during Phase II and, when questioned about their obvious ignorance, admitted that they had received little or no Phase I training—despite assurances by their unit commanders to the contrary. Supervisors, as a result, often suggest (often based on such accounts of inadequate preparation for field practice) that full control over Phase I should be returned to the Training Command, in order to make this part of the training cycle "better and more verifiable." At the same time, however, they acknowledge that putting such a policy into effect will be an uphill battle, considering unit commanders' reluctance to give up their Marines for more than a few days.

Even when trainees receive full Phase I classroom training, either at their units or at a WTBN, there are problems in retention of the material that is presented to them. Instructors have little time to cover many complex topics, including the internal workings of the rifle, the fundamentals of breathing, aiming and trigger control, and the mechanics of sight alignment and sight adjustment. Any one of these topics is difficult for an instructor to convey and for a trainee to assimilate. There is also a general lack of individualized instruction (e.g., coaching and feedback) and a reliance on a passive learning process (listening to rather than engaging with the material). Many trainees report getting relatively little out of Phase I. Other factors, including poor acoustics, lack of air conditioning or heating,

and dryness of content, also make it difficult for trainees to pay attention to, and thus learn, the fundamental concepts and procedures presented in Phase I lectures.

Phase II. Participant observation on the firing range confirmed just how difficult it is for shooters who have not mastered the fundamentals during Phase I to use their practice time effectively during the Phase II field practice. Without a clear understanding of the fundamentals, trainees cannot effectively diagnose and remedy their deficiencies during the four days of practice that they are afforded. Trainees have particular difficulty determining whether their inaccurate firing patterns are the result of poor body positioning, incorrect sight adjustment, or both. As a result of this confusion, struggling shooters spend a significant portion of their valuable practice time floundering, rather than systematically honing their skills for qualifying day. In some cases, trainees become so frustrated that they attempt to qualify early, despite being unprepared to do so, because the practice does not seem to be improving their skills. Another clear sign of frustration is the refusal of many of those who fail to qualify, on their first attempt, to take advantage of the additional qualification opportunity at the end of Phase II.

Coaches often provide critical assistance to struggling shooters hoping to qualify or to good shooters hoping to qualify as experts, but the individualized instruction only benefits trainees who already have a firm grasp on the basic concepts covered in Phase I. By observing shooters, coaches point out problems with breathing, aiming, and trigger pull that the shooters themselves would have difficulty identifying. Coaches also make helpful suggestions about adjusting sights to compensate for the effects of weather and distance. To have a lasting effect on shooting proficiency, however, the help that trainees receive from coaches must be internalized and integrated into their own thought processes, so that trainees can do things like adjust windage and elevation settings, as well as modify body positions, on their own. Trainees also have to rely on their own knowledge in order to choose between, or attempt to reconcile, the conflicting advice that they sometimes receive from coaches. It is not unusual for one coach to tell a struggling shooter one thing, and then another to come along and tell him or her the exact opposite, as coaching appears to be as much art as science. In such situations, trainees must be discriminating, selectively integrating the opinions of others into their own personal diagnoses and remedial strategies.

Only by becoming self-sufficient can shooters take the lessons learned during the practice days (when coaches are available) and apply them effectively on

qualification day (when they are not). By way of illustration, a number of trainees interviewed performed well during practice days, as they worked closely with coaches, but then struggled on qualification day because the support systems or "crutches" (trainees' word) upon which they had relied were taken away from them. Because they had not mastered the fundamentals, these trainees had become dependent on coaches, and, thus, were unable to take corrective actions on their own.

Findings Relating to ADL Employment

An important step toward improving the proficiency of shooting in the Marine Corps is to develop a more dynamic and effective way of covering the fundamental concepts in Phase I. ADL can play an important role in a revamped program, but to do so, the new method and tools must be employed in a way that avoids likely pitfalls and enhances potential benefits.

Two forms of ADL technology were available at the WTBN at the time of the study:

1. The MCI automated digitized marksmanship course, on CD-ROM, and
2. The ISMT hardware simulator.

The ISMT had been available for several years at the WTBN, whereas the digitized course had been delivered only a couple of months prior to the researcher's arrival and had not been integrated into the training curriculum. Trainers did not have a clear idea of how the digitized course was intended to be used or what parts of existing training it could supplement/complement/replace. These computer-based instructional tools have the *potential* to improve training, by providing the kind of intensive, individualized instruction, guidance, and feedback that cannot otherwise be provided during Phase I. The ISMT can, in theory, familiarize shooters with the M16A2 and even help diagnose problems with shooting. The digitized marksmanship course has the potential to teach the fundamentals of marksmanship in an engaging way, through the use of interactive, multimedia presentations and exercises. However, the study identified two employment problems and/or obstacles that must be addressed before these ADL technologies can be effectively incorporated into the formal training cycle:

Technology failures have created a negative anticipation. The consensus opinion of those interviewed, trainers and trainees alike, was that the ISMT

hardware simulator had never become an integral part of training, and had gradually fallen out of favor and into disuse, due to technical problems that have plagued the instructional technology. One common complaint heard by the researcher concerned the difficulties that instructors and technicians have had keeping the ISMT operational. It apparently takes a considerable amount of time for a technician to get the simulator working correctly, and even then, the ISMT frequently breaks down during use. The researcher experienced these problems himself when he repeatedly attempted, with no success, to utilize the simulator. Some respondents went so far as to suggest that frustrations and disappointments with the ISMT have created a less than hospitable environment at the Battalion for the introduction of a new ADL product, such as the digitized marksmanship course, regardless of the latter's merits.

Adequate technology access does not yet exist. With only 30 or so computers at the local Learning Resource Center, and approximately 10 stations at the ISMT, there is simply not enough technology available at the Battalion to reach all of the trainees (hundreds) who arrive each week. A program proposed by one Training Command was to target the low-scoring marksman and the shooter who totally fails marksmanship qualification—a small subset of trainees. In order to increase the proficiency of these struggling shooters, the remedial program would put this select group through targeted class sessions utilizing the digitized course. Then, after having their knowledge of basic concepts refreshed, the participants would receive follow-up lessons with the hardware simulator, before being given an additional opportunity to qualify. Although focusing on those who performed poorly on qualification day addresses the problem of accessibility, this type of remediation program creates a problem of sequencing. Selecting trainees for remediation based on results during qualification means that ADL technologies are used after Phase II field practice has been completed. This precludes participants from applying, on the firing line, the lessons that they presumably learned through ADL. Most instructors and coaches interviewed for the study stated that proceeding directly from the follow-up lessons with the ISMT to the additional qualification opportunity would be counterproductive, since there is limited transference of skills from the hardware simulator to the firing range. These experts recommended that participants spend at least one additional day on the firing range before the second attempt at qualification, so that they can consolidate what they have learned during remediation. This raises an important question: Would unit commanders allow their

Marines to stay for the additional day(s) necessary to complete this extended remedial training?

A distance-learning mode of delivery can address the issues of accessibility and sequencing without requiring additional investment in technology, at least in the case of the digitized course. Under this employment strategy, the CD-ROM would be made available at the individual units, so that Marines could access the ADL lessons *prior* to coming to the WTBN. The course would be accessed through existing computers (personal or work), and would either supplement or replace existing Phase I training. Making the ISMT more accessible to trainees, on the other hand, would require a more significant investment.

Next Steps

CRESST will complete analysis of Study C data and will document results of all studies in a Final Report. BTL will document its marksmanship simulations in a Final Report. CHI will extend its study of marksmanship training with a study of how the MCI Rifle Marksmanship online course is being used, and may conduct additional qualitative field-based studies of USMC DL implementations to support development of practical guidelines and procedures for effective DL employment. The Final Reports and prototype assessment and simulation tools will be delivered to ONR, the Camp Lejeune Weapons Training Battalion, and the USMC Training and Education Command.

The KMT project has produced prototype assessment and instructional simulation tools of potential benefit to USMC marksmanship training. The ONR KMT funding is R&D money, however, and cannot support the transition of these tools from Science and Technology (S&T) advanced technology prototypes to the fieldable tools needed for insertion in the marksmanship training process. If transition money were available, either from the Navy or the Marine Corps, the following work might be completed:

- Validation of the assessments' ability to go beyond prediction of overall shooting performance to identify specific knowledge gaps, predict the impact of the missing knowledge on shooting performance, and identify the remediation required to fill the gap.

- Shrink-wrapping, bullet-proofing, and validating a complete assessment and training package based on the prototypes.

- Qualitative studies of the results of fielding the assessment and training package produced with transition funding, including analyses of how organizational processes adapt (or need to adapt) to make effective use of DL delivery, and guidelines and a supporting case study helping the Navy (via NETC) and Marine Corps (via the DLC) better design and employ DL.

In addition, the following work might be considered for additional R&D funding:

- Integrating assessment and training with the forthcoming Marine LOMAH (Location Of Miss And Hit) system. This would make it possible to assess shooting performance directly and automatically, and to select appropriate training modules based on that performance.

- Hand-held assessment and training modules. These could be used to teach data book activities in the context of real shooting environments, with automatic evaluation and feedback. Advice could be provided on the firing line, and instructors could be automatically alerted about problems. If integrated with the LOMAH system, these hand-held devices could also provide feedback and advice about actual shooting performance.

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