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CRITICAL THINKING TRAINING FOR ARMY OFFICERS VOLUME THREE: DEVELOPMENT AND ASSESSMENT OF A WEB-BASED TRAINING PROGRAM

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**U.S. Army Research Institute
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14. ABSTRACT (*Maximum 200 words*): This is the third volume of a three-volume report describing a multi-year research program to develop and validate web based training in critical thinking for Army officers. The first volume presents an overview of the research effort that developed and validated a theoretical model for the training, selected and validated eight high impact critical thinking skills for Army officers, and developed and validated the training course. The second volume describes, in more detail, the model and theoretical basis for the training and the investigations that were conducted to validate the model. This, the third volume, describes the prototype training system that was developed for two of the skills, including the functional requirements, pedagogical principles, course content, and evaluation of the training. A succeeding report (Fischer, Spiker, Harris, McPeters, & Riedel, 2008) describes an expanded training system which provides training for eight critical thinking skills for Army officers.

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EXECUTIVE SUMMARY

Research Requirement:

   Advanced training in critical thinking (CT) is needed for adult populations in many fields of work. Not surprisingly the United States military is at the forefront of the effort to promote and improve thinking skills. Military leadership demands the application of high quality CT for effective battle command. Thus, a new Web-based CT training system, *Computerized Training in Critical Thinking* $(CT)^2$, was developed. The present volume is the third in a three volume report which describe a research program in developing training for critical thinking. The first volume presents an overview of the research effort that developed and validated a theoretical model for the training, selected and validated eight high impact critical thinking skills (CTS) for Army officers, and developed and evaluated a prototype training system. The second volume presents, in more detail, the model and theoretical basis for the training and the investigations that were conducted to validate the model. This volume describes the training that was developed, including the functional requirements, pedagogical principles, learning objectives, organization, course content, and evaluation of the training. The prototype training system described in this volume provides training for two of the eight identified CTS. A succeeding report (Fischer, Spiker, Harris, McPeters, & Riedel, 2008) describes the expanded training system which trains all eight CTS.

Procedure:

   The goal of this research was to create easily accessible, state-of-the-art distance-learning instruction that would effectively train CT. To meet this objective, teaching methods were identified that were likely to be most effective at developing CT in Army officers. Two investigative strategies were adopted to determine the best teaching methods. First, lessons learned from the research literature on training CT and distance-based learning were examined. Second, current efforts to teach CT to Army officers were studied. Army instructors and instructional developers involved in teaching CT were surveyed to identify their successes and problems in teaching CT.. The results from the two research strategies were then used to establish functional requirements for web-based CT instructional material.

   The functional requirements were used to guide the design of $(CT)^2$. A set of pedagogical principles were also derived from the literature review, survey, functional requirements, and practical considerations. These served as the philosophical basis of $(CT)^2$'s design.

   To evaluate the effectiveness, usability, and student acceptance of $(CT)^2$, one module of $(CT)^2$ was assessed. The central objective of the research was to determine whether $(CT)^2$ effectively improves CT compared to two other learning conditions. The research also assessed participating students' attitudes and subjective evaluations of $(CT)^2$ as indicators of acceptance and usability.

Findings:

Examination of the lessons learned from the research literature on training CT and distance-based learning yielded a number of results that were used to guide the development of $(CT)^2$. These are summarized here. The literature indicates that CT can be successfully taught in the classroom or as part of a distance-learning program. However, distance learning does tend to produce lower motivational levels among students who take distance learning courses (Eldred, 1994). Therefore, any attempt to teach CT using distance-learning methods should provide motivational components to counteract the isolation inherent in distance learning. For example, multimedia and interactivity can be used to increase motivation and to increase the efficiency by which information is transmitted to the student. CT training should also include rich and varied examples, which should be presented in real world contexts. Instruction should be context-rich, problem-based, and goal-oriented and should include interactive simulations for demonstration, exploration, and discovery, practice and for transfer of knowledge to new situations. The CT tasks targeted by the training should be selected from the environment to which they will be applied. Therefore, $(CT)^2$ training should target those critical thinking skills that are important and problematic in Army environments.

The results of the survey of Army instructors and curriculum developers involved in teaching and developing instruction for CT indicated that they are mostly satisfied with how CT is taught at the schoolhouse. They believe that CT is adequately covered in the curriculum and that the guiding conception of CT that they use (based on Paul and Elder, 2001) is useful and sufficient. Their experience suggests that realistic, practical exercises that require practicing CT skills are the best way to improve those skills. However, they also say that feedback about students' performance is a necessary feature of practical exercises. They favor rich and varied examples and realistic context for the exercises. Their central complaint as teachers and curriculum developers is that the Army culture tends (1) not to support the slow deliberate thought that characterizes CT, and (2) to discourage innovative thinking. For this reason, some instructors and curriculum developers avoid talking about CT in the abstract. All respondents agreed that it is difficult to convince students of the need and importance of improving their CT skills.

The literature on CT provides a different perspective of how CT should be taught than the recommendations from instructors. These two vantage points seem to yield different, yet compatible, kinds of recommendations. Researchers and instructional experts agree that practical exercises are the best way to teach CT and say that distance based methods may be effective. They agree that examples that are realistic, practical, and context-rich are effective. However, the literature has more to say about methods of training. While instructional experts report satisfaction with current CT theories (Paul & Elder, 2001) and the use of practical exercises as a useful method, the literature suggests that a number of other techniques may be more effective.

The results of the literature review and instructor survey informed the establishment of functional requirements for a distance-learning program of CT training, $(CT)^2$. Functional requirements for such a program were specified, including (1) an estimate of instructional capability, (2) scope of the instructional problem, (3) location of instruction, (4) anticipated

student load, (5) alternative instructional strategies methods, and media, (6) support for providing and maintaining the system, (7) facilities requirements, (8) evaluation and assessment, (9) quality improvement metrics, and (10) other requirements specific to teaching CT in an on-line format.

A set of pedagogical principles were developed based on a review of the literature on training critical thinking and on distance learning. These principles served as the philosophical basis of $(CT)^2$'s design. The principles are:

- *CT skills can be learned, trained, and transferred.*
- *Practice is essential.*
- *Feedback is essential.*
- *Assessment is essential.*
- *Training conditions should optimize transfer.*
- *Part-training methods are most effective.*
- *Focus on important and problematic critical thinking skills.*
- *Focus on common and consequential errors.*
- *Use training methods appropriate for adults (army officers).*
- *Start with concrete experiences..*
- *Training should be scenario based.*
- *Training should be increasingly complex and difficult.*
- *Training should be distance-based.*
- *Multimedia is essential.*
- *Interactivity is essential.*
- *Scoring increases motivation and should be used.*
- *Use innovative training techniques.*

Based on these principles, an on-line CT course, $(CT)^2$, was designed and developed. The focus of $(CT)^2$ is on improving key critical thinking skills that are important and problematic in Army battle command. CT involves a deliberate, systematic awareness of the process and products of one's own thinking. The training program focuses on targeting common – and potentially serious – errors that people make when they fail to apply appropriate critical thinking skills. These errors include overlooking important details, misinterpreting information, and making incorrect assumptions – all of which can lead to poor situation assessment, decision-making, and problem solving. The training program highlights awareness of these errors and teaches specific techniques that can help people overcome them. It presents students with real-world situations and asks them to complete numerous thinking exercises that require the practice and application of CT skills in a variety of realistic settings.

The effectiveness of $(CT)^2$ was assessed in an evaluation in which participants from the 85th Reserve Training Division worked through parts of the training. Although the evaluation sample size was small, $(CT)^2$ was positively rated by all participants. Despite the extensive time commitment the training program requires, users found it interesting and well worth their time.

$(CT)^2$ appears to be generally effective at encouraging critical thinking, at least about messages Army personnel must evaluate. The evaluation showed that the web-based training enhanced memory for messages, possibly because it encourages greater depth of processing. The

finding that memory of messages is enhanced after participating in $(CT)^2$ is a strong indicator that those messages have been processed at a deeper level.

The results suggest that training using $(CT)^2$ inhibits the production of (potentially incorrect) inferences that go beyond what is explicitly given in the message. Participants who took the $(CT)^2$ training made significantly fewer unjustified inferences than participants assigned to the other two training conditions. Examination of the responses reveals that $(CT)^2$ participants did make inferences; however, they justified them by pointing out explicit information given in the message that supported their inferences. $(CT)^2$ appears to encourage discrimination of what is "known" or "given" from what might be added (i.e., inferred) by the perceiver.

Utilization and Dissemination of Findings:

$(CT)^2$ can be used by the Army training and education communities as a tool to improve critical thinking skills in Army officers. The training program is easily accessed on the web and is appropriate for use as stand-alone training for self development, use as distance learning in a school house curriculum, or in a classroom setting as take home work or for in-class exercises. Researchers, teachers, and curriculum developers can use the findings as a stepping-stone to the development of future CT educational programs, or to better understand $(CT)^2$ for their own use.

The prototype training program described in this volume provides training for two CTs. It serves as the pilot system for a larger training program which trains the full set of eight CTS.

CRITICAL THINKING TRAINING FOR ARMY OFFICERS
VOLUME THREE: DEVELOPMENT AND ASSESSMENT OF A WEB-BASED
TRAINING PROGRAM

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INTRODUCTION

Interest in promoting critical thinking (CT) skills has increased over the past 20 years in a variety of diverse applications such as public education, military leadership, nursing, technical vocations, and corporate business. Not surprisingly, the United States military is at the forefront of the effort to promote and improve thinking skills. Military leadership demands the application of high quality CT for effective battle command, where battle command applies "to the leadership element of combat power...Commanders visualize the operation, describe it in terms of intent and guidance, and direct the actions of subordinates within their intent. They directly influence operations by personal presence…" (Department of the Army, 2001. Section 5-1). For this reason a new Web-based CT training system, Computerized Training in Critical Thinking $(CT)^2$, was developed.

The present report is the third in a series of three volumes which describe a research program in developing training for critical thinking which culminated in the development of $(CT)^2$. The first volume (Fischer, Spiker, & Riedel, 2008a) presents an overview of the research program that developed and validated a theoretical model for the training, selected and validated eight high impact critical thinking skills for Army officers, and developed and evaluated the training course. The second volume (Fischer, Spiker, & Riedel, 2008b) presents, in more detail, the model and theoretical basis for the training and the investigations that were conducted to validate the model. This volume describes the prototype training system that was developed, including the functional requirements, pedagogical principles, learning objectives, course organization and content, and evaluation of training. A fourth report (Fischer, Spiker, Harris, McPeters, & Riedel, 2008) describes the expanded training system and its assessment.

Promoting CT Through Training

Advanced training in CT is needed for adult populations in many fields of work. Several domains (e.g., nursing, business, military leadership) have recognized the need to improve the CT of personnel whose cognitive skills they suspect are deficient (e.g., Hawley, 1998). It is not surprising that CT ability may be substandard because education in nearly all areas has traditionally focused on the accumulation of content knowledge, often neglecting to teach the reasoning skills that process such knowledge. Tucker (1996, p. 46) remarks that, "while content knowledge is a crucial part of this value creation, critical thinking skills are the adjudicative engines that drive everything from boardroom strategic decisions to the creative responses of a software company's help desk." In short, education and training may not have kept up with changes in demand.

CT Training in the Military

Military leadership demands the application of high quality CT for effective battle command and United States military educational institutions recognize the importance of promoting and improving critical thinking skills. Military leaders must make tactical decisions in complex and stressful situations where knowledge is incomplete and uncertain. The information provided to a battle commander is always incomplete, often inaccurate, and sometimes purposefully misleading. CT skills involving the evaluation of battlefield information is crucial under these circumstances. Moreover, a leader's ultimate solutions to battle command problems must be effective, yet not be predictable. Therefore, he cannot simply base his battle plans on well-learned battlefield patterns; he must reason through and integrate an enormous amount of information. Army leaders are finding themselves in situations that bear little resemblance to conflict situations they have previously experienced or studied. In such situations, novel solutions that are the product of CT will be critical to success.

Sometimes battle commanders must make rapid decisions in situations where there may not be time for extensive CT. Other times, however, a battle commander may have several days to develop his plan and issue orders, which is sufficient time to apply concentrated thinking. In cases where the ensuing situation requires rapid decision-making, even an available 20 minutes may provide an opportunity to apply CT. In fact, CT becomes even more important in the execution, as opposed to the planning, phase of battle because events rarely occur in concordance with the original plan. CT is not only critical for commanders at all echelon levels, but also for staff officers who are responsible for summarizing large quantities of information from numerous sources, or for making recommendations to the commander. In summary, battle command is clearly a domain in which CT is important to performance.

Extensive training time is devoted to the accumulation of content knowledge in the military. For example, every Army officer studies Clausewitz's principles of warfare. Traditional Army education offers a prescriptive model that corresponds to doctrine, and focuses on the products of decision-making (Fallesen, Michel, Lussier, & Pounds,1996). Historically, relatively little training time has been spent on improving the process of thinking and decision-making[1]. It is not that the Army educational system has neglected to provide instruction in critical thinking or reasoning, but that fewer resources have been devoted to the training of thinking processes than to other important skills. Moreover, the prescriptive and procedural nature of the doctrinal methods may actually discourage the application or development of thinking skills, inhibiting the creation of novel solutions that might be the result of CT. Combat Training Center experiences tend to reinforce the schoolhouse model of doctrinal decision making by evaluating unit performance based on adherence to a prescriptive model. In so doing, they tend to encourage an algorithmic approach to command decision-making and discourage flexible and thoughtful approaches to meeting the objectives of the mission (Fallesen, et al., 1996).

If relatively few resources are devoted to developing good thinking habits, officers must develop and hone their own methods of thinking to support decision-making. Without explicit training, whatever thinking skills a military leader possesses are gained through on-the-job

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[1] However, the new Intermediate Level Education program at the Army Command and General Staff College includes training in critical thinking that is integrated into every lesson plan.

experience, fortuitous experiences in training exercises, individual disposition, or other means such as self-study. Establishing an integrated training program to address the development of thinking skills in battlefield commanders is clearly preferable to hoping that these skills will develop on their own. In short, the education of military commanders seems a ripe opportunity for developing training designed to foster thinking skills, and that the domain of battle command is one in which CT is crucial. However, the development of superior critical thinking skills requires extensive deliberate practice and sometimes unpleasant intellectual work (Paul & Elder, 2001). As is necessary to develop any complex skill (e.g., a tennis serve), developing proficient CT habits also requires excellent coaching, internal motivation, self-awareness, and the ability to critically evaluate one's own performance (Paul & Elder, 2001).

Development of training that effectively and efficiently improves critical thinking skills that underlie proficient battle command rests on the ability to identify such skills. Before effective training can be developed, training objectives must be specified, and those objectives should be derived from an empirically tested model of CT. In the second volume of this series (Fischer, et al., 2007b), such a model was described.

This CT model has been used to guide two major efforts to develop CT training curriculum. The Intermediate Educational Level (ILE) team at the Command and General Staff College (CGSC) at Fort Leavenworth, Kansas, conducted the first effort. In the summer of 2000, the ILE training development team was tasked with developing new curriculum. The ILE team based their CT training on the model of CT and the associated research described in Volume Two of this series, which identifies a set of eight critical thinking skills that are important and problematic to Army battle command.

The CT model was also used to guide development of a new training program that promotes CT in Army officers. Research results reported in Volume Two (Fischer, et al., 2008b) indicated that additional training was needed that could be easily and widely accessed by Army officers throughout the world. A needs analysis indicated that the training should be distance-based and a new Web-based CT training system was developed, *Computerized Training in Critical Thinking* (CT)^2. The present volume documents the research and development effort that produced the prototype version of (CT)^2. This volume also documents the pedagogical strategy, learning objectives, organization, and lessons of the web-based training. Finally, it describes and discusses the results of an evaluation of (CT)^2.

LESSONS LEARNED ABOUT TRAINING CRITICAL THINKING

The primary goal for $(CT)^2$ was easily accessed, state-of-the-art distance-learning instruction that would effectively train critical thinking skills (CTS) for Army officers.. The first step in meeting this goal was the identification of CTS to train. To address this issue, research (Fischer, et al., 2008b) identified a set of critical thinking skills as important and problematic to Army officers. In developing $(CT)^2$, it was also important to employ the best-known techniques for promoting CT and distance-based training. The second step then in developing $(CT)^2$ was the identification of teaching methods that are likely to be most effective at developing CT in Army officers.

Two investigative strategies were adopted to determine the best methods. First, lessons learned from the research literature on training CT and distance-based learning were studied. Identification of lessons learned from others' experiences was an efficient and cost-effective method to avoid blind alleys, recapture earlier successes, and gain low-cost insights into potential problem areas. The education and psychology literature was reviewed to determine the types of CT skills for which training has been developed, the methods used to teach such skills, and the methods that have been shown to be most effective.

Second, current efforts to teach CT to Army officers were studied. Army instructors and instructional developers who are involved in teaching CT were surveyed to identify the successes and the problems they experienced related to training CT. The survey focused on the content and organization of current CT courses as well the instructors' experiences and opinions about teaching CT to Army officers. The survey was designed to reveal lessons learned from current efforts to promote CT within the military training system.

The results from the two research strategies were then used to establish functional requirements for web-based CT instructional material, which are discussed later in this report. The methods, results, and conclusions of the CT training literature review and examination of current teaching methods are provided below.

Lessons Learned from Past Research

What methods have been used and evaluated for teaching CT? What kinds of CT skills have educators and researchers targeted? Which methods are most effective for promoting CT? How can the best teaching methods be implemented in a distance learning application? To answer these questions, a literature review was conducted that encompassed academic sources from the fields of education and psychology.

A variety of key words were used to search key databases, each relevant to development of web-based training of CT. Key words were combined to narrow the search to articles relevant to training and education, with a particular emphasis on distance, computer-based, and web-based instruction, such as "critical thinking," "training," "education," "instruction," web-based," "computer-based," and "distance learning." The Internet was also searched for sites pertaining to web-based training, distance learning, and CT training. This search strategy produced over 1000 hits. When redundancies among item content were eliminated, the list of sources to review was

reduced to 134 sources. However, many of the sources were only tangentially related to training CT. Of the 134 sources, 43 (books, articles, reports, and websites pages) directly related to the issue of teaching CT were obtained and reviewed. An additional 29 sources relating to distance learning, web-based training, and computer-based training were reviewed. Below, we summarize the findings and conclusions of the review, organized by the central questions we sought to resolve.

What Critical Thinking Skills Are Taught?

Volume Two of this series (Fischer, et al., 2008b) discusses the critical thinking skills that theorists have proposed are important to common cognitive tasks and contains a list of critical thinking skills appearing in the literature. For convenience sake, this list is reprinted in Appendix A of this volume. The skills listed in Appendix A were used to organize the information that we gathered in the literature review about CT training methods. The skill that was discussed and/or trained in each source was first identified as one of the CT skills listed in Appendix A. The teaching method(s) used to promote each critical thinking skill was then recorded.

Appendix B of this report summarizes the kinds of skills for which researchers have developed training materials or techniques and the teaching methods used for each skill. Appendix B also identifies the reference from which each training method was identified, and the kind of evidence provided by each source. It is clear from Appendix B that educational researchers have attempted to teach a wide variety of critical thinking skills (CTS). However, it is also clear that training methods have not been developed for many of the skills listed in Appendix A. For example, argument analysis skills have frequently been targeted by teaching students to distinguish among assumptions, evidence, and conclusions, and by having students critique arguments. Meta-critical thinking skills, however, have received much less attention. Therefore, of the many possible critical thinking skills that could be developed through training, only a few have been systematically targeted. It appears that scientists and educators have focused on developing only a small set of CTS.

It is not clear why some CTS have received attention and others have not. Researchers have a variety of purposes, biases, and preferences, which may drive their interest in some CTS but not others. Little attempt has been placed on establishing the relative importance of CTS, which may vary depending on the environment in which they are applied. Little attempt has been made to organize the CTS in some meaningful way that would facilitate their selection for training.

What Methods Are Used To Teach CT?

To simplify the diverse teaching methods identified in Appendix B, each was classified as one of seven general methods, which include: (1) overt argument analysis, (2) applied argument analysis, (3) evidence-based or scientific analysis, (4) meta-cognitive strategies, (5) question asking or the Socratic method, (6) group discussion, and (7) guided practice. These seven general categories are defined below.

Argument analysis is a popular and common teaching strategy used to promote CT. Argument analysis can be either overt or applied. *Overt argument analysis* (e.g., Bernstein, 1995) requires students to evaluate competing arguments. It explicitly teaches students about concepts such as assumptions, claims, evidence, etc. For example, students may be taught to analyze and evaluate competing arguments on an issue. Instructors may then have their class engage in discussions about the arguments. Another example of overt argument analysis is explicit instruction in standards for forming generalizations. In contrast, methods that use *applied argument analysis* (Colbert,1986) are embedded in activities such as negotiation, debate, and generating predicted consequences of actions within specified topic areas. For example, students may learn to analyze arguments by engaging in a negotiation or a debate process with another student who has taken an opposite position on a particular issue.

Methods that use *evidence-based analysis* (Zobar, Weinberger, & Tamir, 1994) emphasize the logic inherent in the scientific method. In such methods, analysis of experiments, problem solving, and data handling may be taught. For example, some researchers suggest that the explicit teaching of experimental research methods increases CT. Another kind of method, *Meta-cognitive strategy,* teaches students how to think about their own thinking. For example, Klein, Olson, and Stanovich (1997) taught students to plan for monitoring their evaluation of an argument by reminding themselves that they would either be a "careful idea shopper," or "try to figure out what the author wants me to believe." Paul and Elder's widely used CT textbook (2001) also encourages meta-cognitive development by having students think about their current habits of thinking. Each chapter contains several exercises in which students are directed to examine some component of their habitual thought processes.

Another popular method for promoting CT, the *Socratic* method (Jones & Safrit, 1994), requires students to answer or generate questions. The Socratic teaching method is a loosely related family of pedagogical techniques that vary substantially in purpose, design, and outcome. The only thread that unites these methods is the inclusion of questions. In its original form, the Socratic method was used to illuminate the logical fallacies of an individual's beliefs and attitudes. It was a method that could only be applied "one-on-one," because it was designed to make a single student question his/her positions. Socrates himself claimed to be ignorant of the "truth" and would ask the student questions to determine the veracity of positions the student held. Socrates then examined the logical consequences of each answer. The usual conclusion of a Socratic session was to show the contradictory assumptions and conclusions inherent in the reasoning held by the student. In so doing, Socrates improved the CT of a particular student by encouraging reexamination of his/her argument.

Teachers have modified Socrates' original method in many different ways. For example, questioning techniques may be used to motivate students rather than to illuminate logical inconsistencies in their students' beliefs (Hittner, 1999). Law schools are famous for the use of questioning to promote motivation, where students must be well prepared to answer any question in the classroom, or risk humiliation. Law schools also use questioning to encourage students to back up their reasoning with evidence. "Socratic" methods also vary in the *types* of questions that are posed to students. Some techniques use questions that have factual answers that students can easily provide. Others use questions that require creative answers because there is no single

correct response. While Socrates applied his technique to individuals, current questioning methods are typically applied in a group discussion format.

In fact, *Group discussion* (e.g., Garside, 1996) is the most common means used to promote CT in the classroom. Group discussion is thought to improve CTS by exposing students to perspectives other than their own. Other *social* teaching methods used to promote CT include collaborative learning, the introduction of controversy in class discussion, and group assignments that ask students to identify causes of events, develop explanations for phenomena, etc.

Guided practice (e.g., Jones & Safrit, 1994)*,* another method used to improve CTS, requires students to practice CT skills under the tutorship and guidance of a teacher who also models performance. For example, students may be asked to role play or dramatize a decision maker or problem solver.

Certain kinds of teaching methods are probably better suited for improving some critical thinking skills than for others. For example, the *Socratic method* may be more appropriate for tasks that involve the creative generation of solutions such as inductive reasoning. Alternatively, overt argument analysis teaching methods are probably more effective at promoting tasks that involve deductive reasoning. Unfortunately, little is known about which methods are most effective at teaching particular tasks. Below, we discuss the current state of knowledge about the effectiveness of these teaching methods.

Which Teaching Methods Are Most Effective?

Appendix B shows that a small proportion of the methods that have been used to promote CT have been empirically validated. Most of the sources we reviewed described pedagogical methods that were employed in existing classrooms. Many failed to report quantitative, or even qualitative, measures of performance after the training was delivered. The literature cited in Appendix B contains a large number of opinion papers and testimonials assuring readers that, in the author's experience, the methods work well to increase CT. Unfortunately, testimonial evidence is often biased. If empirical evidence is applied as a standard, we must conclude that current research lacks information about the effectiveness of CT teaching methods.

A second problem is that many of the empirical investigations summarized in Appendix B have been conducted on training effectiveness are large-scale program evaluations (e.g., Herrnstein, Nickerson, de Sanchez, & Swets, 1986; Klein, Olson, & Stanovich, 1997). For example, Herrnstein, et al., (1986) implemented a large-scale educational program in Venezuela that included 6 schools and over 400 students. The educational program was designed to increase Venezuelan school children's levels of thinking, and used many methods to achieve its goals. In one method, students were given explicit and overt training in reasoning and guided practice. In another, CT training was embedded in content courseware and instructional methods. Although findings of the research were robust and found that clear improvements had been made in CT, the evaluation design precluded determining which methods were effective. Programmatic evaluations such as the Herrnstein, et al., (1986) research do little to help instructional designers who are seeking ways to include CT training in their curriculum because they fail to identify the specific techniques are effective in training CT.

A third problem is that the CT training literature is as fragmented as the CT theoretical literature, primarily due to disagreement on the definition of CT. Researchers are eclectic when choosing CT skills on which to focus their training. Some focus on a single skill, such as making reasoned valued judgments, because they limit CT to this narrow definition. Others train a host of skills that typically fall into the category of reasoning because they see CT as a cognitive activity that primarily involves formal and informal logic. The literature is also fragmented because the teaching methods and techniques reported are largely idiosyncratic to the particular author reporting the technique. Thus, very little overlap appears among teaching methods. The fragmentation of the training literature makes it difficult to compare studies.

In conclusion, in our opinion based on the review summarized in Appendix B, current research lacks empirical evidence that would guide selection of teaching methods to promote CT. However, the literature does provide the instructional developer with a set of potential methods from which to select a pedagogical strategy. New efforts to train CT could consider argument analysis, evidence-based analysis, meta-cognitive strategies, questioning, group exercises, and modeling as approaches that might improve CT.

Many of these methods are typically applied to group settings and capitalize on the individual differences inherent in groups. Methods that could be taught individually (e.g., argument and evidence-based analysis) are, nonetheless, most often used in social situations. The relative contribution of natural group dynamics to the promotion of CT is not known. While some researchers (e.g., Bernstein, 1995) claim that group discussion is most effective at improving CT, we do not know if the true source of improvement is the group dynamics inherent in the situation or the teaching strategies used.

Distance Learning. The question of whether CT can be improved using distance learning techniques is unresolved at this point. It is important to consider the effectiveness of distance learning, notably computer-based training, as it has been applied to the development of knowledge and skills of other domains. A brief review of the literature on distance learning is provided here.

Distance learning has traditionally referred to situations in which the teacher and learner are separated by time and/or space, with communication occurring through the mail, by phone, or by video. More recently, the term has been broadened to refer to any arrangement in which instruction occurs through a medium other than face-to-face (Imel, 1998). The learner may reside in the same town and may even be a student on campus and still be a distance learner if he or she accesses course materials on the computer or interacts with the teacher through the Internet.

While Edelson (1998) claims that Internet courses have "clearly emerged as the technology-of-choice" among part-time adult students who are unable to attend conventional classes, Ostendorf (as cited in Imel, 1998) declares the most popular and fastest growing distance education delivery mode in the US is live video instruction. Other forms of distance education include synchronous, interactive audio conferencing over phone lines, and asynchronous, non-interactive print or video recordings (Mylona, 1999).

Most studies comparing the effectiveness of distance learning with traditional instruction have found no difference in learning outcomes (Barry & Runyan, 1995; Hiltz, 1990; Schlosser & Anderson, 1994). Clark (1994) concludes that it is not whether education is provided at a distance that makes the difference in student learning but the quality of the instruction itself. One disadvantage of distance learning is that students commonly feel disconnected from others taking the course and from the instructor, which can cause anxiety. Perhaps this is one factor that causes the much higher dropout rate associated with distance learning. However, student support groups can reduce feelings of isolation.

Distance learning also requires more self-motivation from the learners than traditional educational methods (Eldred, 1994). Students must maintain their attention and concentration on the material to be learned without the motivating presence of an instructor. However, well-designed computer-based instruction could provide motivation in other ways, as could student support groups or learning teams.

One type of distance learning, computer-based instruction (CBI) or computer-based training (CBT), has been shown to significantly improve student achievement. A 1990 US Institute for Defense analysis of 47 studies comparing the use of interactive computer videodisc education with traditional classroom education found CBT more effective for knowledge and performance, with lower attrition rates and instructional costs and a 31% reduction in learning time (Fletcher, 1990). Student learning data from the University of Melbourne suggest enhanced learning through CBI (Wills & McNaught, 1996). Other studies have shown CBT to be at least as effective as traditional learning, with large decreases in learning time observed (Riding & Chambers, 1992).

Effective CBT is not just text on the screen. The use of interactivity and multimedia are crucial for high learning outcomes. Interactivity includes the traditional instructional features of stimulus, response, and feedback, as well as computer-based simulations in which students can manipulate systems and observe the results of their actions. Interactive simulations provide opportunities for active and constructive learning, and help make abstract concepts concrete (Rieber & Parmley, 1995). Micro worlds are elaborate simulated environments in which students explore to learn about specific domains. The use of ThinkerTools, a micro world designed to teach Newtonian physics, resulted in sixth-grade students who outperformed high school students in a traditional physics class (White, 1993). Other examples include a simulated cardiovascular system that reduced misconceptions in biology students (Windschitl & Andre, 1998) and an interactive simulation of projectile motion, which resulted in significant improvement in physics knowledge (Rieber & Parmley, 1995).

Multimedia is the combination of different presentation modes, such as words and pictures, and different sensory modalities, such as acoustic and visual. Mayer (1997) reviewed an extensive series of studies that support the superiority of learning with multimedia, including the coordinated presentation of explanatory words and pictures and the simultaneous presentation of narration and animation. In an examination of six controlled environments directly comparing traditional classroom instruction to equivalent interactive multimedia instruction at companies such as IBM and Xerox, CBI resulted in 56% more learning in 38-70% less time.

An advanced form of CBT is the intelligent tutoring system (ITS). ITS is different from standard CBT in that it incorporates an ongoing analysis of the student's ability and specific instructional needs, continually modifying the instruction to fit those needs. There is currently controversy over the appropriateness of a student model, with constructivists claiming that knowledge is not fixed but is constantly changing within the context of new experiences and ideas. However, the usefulness of a student model for enabling systems to adapt to learners' needs has been strongly supported (Akhras & Self, 2000). Shute and Psotka (1994) present studies of six existing ITSs, each of which have demonstrated accelerated learning.

With the current attitude in education leaning toward the desirability of collaborative learning environments, in which students interact and share knowledge and view points, effective CBT will need to find a way to incorporate student collaboration. However, the bottom line with respect to the controversy over CBT vs. traditional classroom instruction is the consensus that good quality instructional design will result in high levels of learning regardless of the delivery format.

CBT and distance learning are combined in Web-based training (WBT). WBT incorporates the computer and the Internet to provide instruction and communication to distance learners. Typically, CBT is downloaded from a website to the learner's computer or run directly from the server. However, in some instances training can be directly accessed from web pages. Advantages of WBT include the ease of revising curricula, consistency in instruction across distributed locations (e.g., military bases), and the convenience of the learner's having access to the instruction at any time. A further advantage is the ability to provide opportunities for collaboration among students via chat rooms, bulletin boards, list servers, and e-mail, if appropriate for the training (Palloff & Pratt, 1999).

A key issue for CBT and WBT is the effect of computer skills and typing skills. Those who are not as comfortable using computer interfaces or a mouse will be at a disadvantage in navigating the environment and manipulating on-screen objects. Those with lesser typing skills will be at a disadvantage in on-line communications, particularly in real-time chat or instant messaging situations. However, with the rapid spread of computers in schools, businesses, and homes, lack of computer and typing skills will be a decreasingly important problem.

Another issue for WBT is that, in our opinion, the Internet currently provides much less interactive and multimedia capability than CBT. Internet browsers are partly to blame for this limitation. They are designed to deliver information in a page-by-page format, which may constrain the design of some training packages. They also do not provide the functionality offered by other programming languages used in CBT. Limits in bandwidth on the Internet are also to blame. For example, the slowness of dial-up access to the Internet would severely limit the number of large sound files and graphics that one might want to include in WBT. However, technology advances may soon eliminate these limitations.

Conclusions

In conclusion, there is no reason to believe that CT can be taught only in the classroom. Distance learning has been effectively used to promote better learning of complex cognitive

skills compared to traditional classroom methods. Research has shown that distance learning can be superior to other forms of training. Therefore, it is likely that it can also be effectively used to improve CT in adult and juvenile populations. However, distance learning does produce lower motivational levels among students who partake in it. Thus, any attempt to teach CT using distance-learning methods should provide motivational components to counteract the isolation inherent in distance learning. Multimedia and interactivity should also be used to increase motivation and to increase the efficiency by which information is transmitted to the student. If an adequate level of interactivity can be provided, as determined by the instructional goals of the training, WBT can be used to effectively teach CT. WBT facilitates the use of chat rooms, e-mail, bulletin boards, which can provide the student with a social network needed to maintain interest and combat isolation. WBT is also easy to modify and distribute in a timely fashion.

Recent instructional theories indicate that CT training should include rich and varied examples, which should be presented in real world contexts. All of these desirable educational elements discussed above can be incorporated into a WBT program. The training program should be a highly interactive and multimedia, computer-based system. Instruction should be context-rich, problem-based, and goal-oriented, and should include interactive simulations for demonstration, exploration, and discovery, and some collaborative environments for practice and transfer of knowledge to new situations.

The critical thinking skills targeted by the training should be selected for the environment in which they will be applied. For Army officers, training should target those skills important and problematic to the Army. Moreover, training methods should be selected that will be most effective for the particular task to be trained. For example, if one were to train the task, *Develop a plausible explanation*, one should focus on evidence-based training techniques that will help the student evaluate evidence and alternative explanations of that evidence. In contrast, guided practice might be used to identify weak or ambiguous components of a message to train the skill *Frame the Message*.

Lessons Learned from Army Instructors and Instructional Developers

The Army currently incorporates training of CT in its schoolhouse curriculum (Bralley, 2006). Although not as systematic or universal as the schoolhouse training, CT education also occurs informally in field units through experiences and mentoring. Examination of current methods of teaching CT is important so as to capitalize on lessons learned. The research described below was conducted to assess instructors' experience in the teaching of CT.

Method

Participants. Eight instructors and instructional developers participated in the survey. Respondents were Army officers or civilian researchers currently working at CGSC at Fort Leavenworth, Kansas State University, or the Army War College, The CGSC instructors taught at the School for Command Preparation (SCP), the Command General Staff Officers Course (CGSOC), and the Combined Arms Services Staff School (CAS[3]). The respondent from Kansas State University was a Professor of Military Science.

Ten potential respondents to the survey were originally identified from their participation in a Critical Thinking Workshop sponsored by the Army Research Institute at Fort Leavenworth, Kansas (Riedel, Morath, & McGonigle, 2001). . Each of the ten were contacted and recruited through phone and e-mail messages, and eight agreed to volunteer their time to participate in the investigation.

Three respondents were Lieutenant Colonels, and one was a Major. Most of the civilian respondents were researchers and instructional developers at CGSC and one was an instructor at the Army War College. Their years of experience teaching CT to Army officers ranged from 1–4 years. Each held either a masters or a doctoral degree. Instructors typically taught only one course, but most had taught at least six courses that involved CT. Instructional developers had been involved in the development of several CT curricula.

Survey Materials. Respondents completed a three-section survey that assessed demographic information and their work experience teaching or developing curricula for CT, the classes they taught that involved CT, and their opinions and experiences in teaching CT. The first section of the survey asked respondents to provide information about their educational background, the number of years they had taught CT, and their current duty position. The second section contained eleven items that addressed respondents' current approaches to teaching CT. The open-ended items solicited information about the guiding theory used to develop the curricula in their courses; whether CT was taught overtly, covertly, in the abstract, or in the context of military situations; the CT skills that are taught; the format of delivery of the course materials; the duration and organization of the course; and assessment measures and feedback used in the course. The third section requested lessons learned from the instructors' and developers' experience in teaching CT. The items solicited opinions and judgments. For example, instructors were asked if CT was adequately covered; whether the skills transferred to the field; whether the guiding theory was adequate; whether CT should be taught overtly, covertly, in the abstract, or in the context of military situations; and whether assessment tools and feedback are adequate. They were also asked to identify their successes and difficulties in teaching CT to Army personnel.

Procedure. Respondents were sent and asked to complete the survey material. When they had completed the survey, they returned their written responses and contacted the researchers. An interview was then scheduled. During the interview, the survey administrator asked each respondent to clarify and elaborate those answers that were not completely understandable from the written responses.

Results

The survey results are given below, organized by the survey's two major questions. First, we discuss participants' responses concerning CT courses they currently teach. Second, we report the lessons instructors and instructional developers learned from their experiences.

Lessons Learned from Teaching CT in the Army. The respondents' answers to the third section of the survey were highly informative about the nature of teaching CT to Army officers. The first question in the survey addressed the adequacy of the CT instruction in the Army.

Is CT adequately covered in the present curriculum? Each instructor felt that within the courses they taught, CT was adequately covered. However, each also believed that CT instruction needed to be extended to and embedded within the Army curriculum as a whole. Particular need was seen for instruction at junior officer levels.

Does CT transfer to the combat environment?. Respondents provided equivocal answers to this question. Generally, it is impossible to know whether the skills that are taught in the schoolhouse transfer to the combat environment because assessment measures have not been developed and applied. However, some instructors thought that CT definitely transfers to the combat environment. Based on their experience at the National Training Center where they had observed success when CT was used and failures when it was not, these instructors were convinced of CT's efficacy.

Does the guiding theory, i.e. Richard Paul's conception of CT, provide adequate direction for the development of instruction?. At the time of the survey, CGSC and Army War College courses were guided by Paul's (e.g. Paul & Elder, 2001) writings about critical thinking. All CGSC and Army War College instructors felt that Paul's theory was adequate. They appreciated the normative standards, which permitted them to formulate feedback and ask questions within class.

Should CT be taught in the abstract or in the context of the domain? Should CT be taught covertly or overtly?. Respondents were in strong disagreement on these topics. Some felt that CT should be taught covertly because adult learners, particularly military officers, fail to see the utility of overtly being taught how to think better. For these instructors, their student population will accept and benefit more from exercises that focus on improving thinking skills. However, they will reject any effort to directly teach those skills in an abstract and overt way. It may be possible to come back to the abstract principles after students have experienced improved CT through practical exercises within the domain of military situations. However, some instructors felt that the teaching of abstract principles was not necessary. On the other hand, some instructors saw the overt and abstract principles as useful, although they also thought it should be taught at more junior levels. It may be that overt pedagogy of abstract principles such as identifying assumptions, deductive logic, and making sound generalizations should be taught early in officers' careers, when the issues of adult learning, years of experience, and vast amounts of existing knowledge within students are not so robust. Another resolution to the argument would be to begin with covert instruction, and only at the end, provide instruction on the CT that students have been engaging.

What methods work best? Instructor opinion was unanimous on this question. All instructors agreed that practical exercises work best. Instructors did not say that other methods are not effective. For example, practical exercises may do little if not followed up with feedback and delivery of information. Instructors, nonetheless, saw the most improvement in their students when given exercises that allowed them to practice their thinking skills in a hands-on context.

What successes have been experienced? Generally, instructors felt evidence of their successes came from their students. Each reported that student evaluations, comments, and performance improvements were the biggest achievements they had experienced in teaching CT. They reported improvement in student decision making, as well as in the quality of their thinking. Some instructors thought that students were better able to prepare for and deliver briefings.

What are the biggest problems? The biggest difficulty instructors said they faced comes from the Army itself. That is, the Army culture tends to discourage critical thinking to some extent. Because of the Army's hierarchical nature and the requirement for unit cohesiveness, respondents said thinking "out of the box" is often discouraged by leaders and by doctrine. Officers are given checklists even for the most critical decisions and tasks, such as mission analysis. Thus, the culture tends to create a certain mistrust of critical thinking and creates a corresponding emphasis on decision-making and action. All of this tends to decrease acceptance of instruction that focuses on improving critical thinking. Elective courses in CT typically have low enrollments. Another critical issue is that the instructors themselves need better training.

Conclusions

In summary, instructors and curriculum developers are mostly satisfied with how CT is taught at the schoolhouse. They believe that it is adequately covered and that the guiding conception of CT (Paul & Elder, 2001) is useful and sufficient. Their experiences suggest that realistic, practical exercises that require practicing CT are the best way to improve thinking skills. They also recognize that feedback about students' performance is a necessary feature of practical exercises. They favor rich and varied examples and realistic context for the exercises. Their central complaint as teachers and curriculum developers is that the Army culture tends to (1) create suspicion about slow deliberate thought that characterizes CT, and (2) discourage innovative thinking. For this reason, some instructors and curriculum developers avoid talking about CT in the abstract. For example, they avoid instruction that refers to various models of CT and even avoid the term, CT. Instead, they attempt to encourage development of CT using covert methods. Other respondents thought it was useful to present and discuss models of CT,

The literature on CT provides a different perspective of how CT should be taught than the recommendations from instructors based on years of experience. These two vantage points do not necessarily yield contradictory advice for new CT learning programs, however. Researchers and instructional experts agree that practical exercises are the best way to teach CT and acknowledge the possibility that distance based methods may be effective. They also agree that examples that are realistic, practical, and context-rich are effective. However, the literature has more to say about what to train and methods of training. While instructional experts report satisfaction with current CT theories (Paul & Elder, 2001) and the use of practical exercises as a useful method, the literature suggests that other techniques may be more effective.

The results of the literature review and instructor survey informed the development of functional requirements for a distance-learning program of CT training. These requirements are discussed in the next section.

REQUIREMENTS FOR WEB-BASED TRAINING
OF CRITICAL THINKING

To lay the groundwork for designing an Internet-based CT training program, an Instructional Systems Design (ISD) analysis was performed. The first steps in ISD include specification of an initial estimate of the capabilities of proposed instruction, the scope of the instructional problem, the location of instruction, anticipated student load, alternative instructional strategies, support for maintaining the system, facilities requirements, evaluation assessment, quality improvement metrics, and funding requirements.

In addition to the literature review and Survey described above, specification of the functional requirements was partially addressed by conducting interviews with members of the Intermediate Level Education team which was responsible for revising CGSOC curriculum in 2001. We also observed lessons in CT given at the School for Command Preparation (SCP) at CGSC. The results of our analysis are given below.

Functional Requirements

Estimate of Instructional Capability

To aid in estimating the proposed training system's instructional capability, its purpose and format were specified. The Army provides officers with a variety of educational experiences that include training in CT. Sometimes that training is embedded in courses on other topics (e.g., tactics, leadership, etc.), and sometimes CT is the focus of the educational experience. Interview respondents suggested that what is needed is courseware that (1) can be accessed by any officer anywhere in the world, and (2) contains lessons apparently not addressed by current training. We made several assumptions, supported by our observations and interviews, in specifying the purpose of the proposed training program. First, we assumed that Army officers currently employ CT in the conduct of their work. In other words, they already have a certain level of CT skill. Second, we assumed that the existing CT training offered by the Army supports development of the skills Army officers currently employ. Third, we assumed that any problems in CT experienced by Army personnel reflect deficiencies that additional training should target. Therefore, the following specifications regarding the *purpose* of the new training were derived. This new CT training should be easily accessible on the Internet to provide maximal distribution to Army personnel. It should complement and support the Army's courseware for leadership (FM 6-22) and other currently provided educational experiences and training in CT. Finally, it should address deficits in officers' CT as manifested by observed deficiencies and errors in human performance associated with common battle command tasks, notably those that involve the Military Decision Making Process (MDMP).

The following specifications regarding the *format* of the new training were derived. First, the new system should be self-directed WBT that is modularly organized around a core . The skills should be important and problematic for mission completion. The training should be disseminated over the Web via a user interface formatted within an Internet browser environment. To encourage commitment and diminish dropout rates, and ensure realism that will

improve transfer to real world situations, it should employ multimedia presentations that include charts, maps, sketches, video, and animation. To ensure that it supports and complements existing training, concepts based on CGSC's adopted Experiential Learning Model (ELM), discussed in detail below, should be embedded in its design. Finally, to assist instructors who might use the system, it should incorporate performance and knowledge assessment throughout each module, with multiple branch points to support individualized remediation.

Scope of Instructional Problem

The instruction should focus on a set of critical thinking skills that are important and problematic to battle command and the MDMP. Each skill should be trained separately and independent from the rest to meet the practical needs of instructors and students.

Location(s) of Instruction

The bulk of instruction should be located on the Internet, accessible through an Army-provided URL. Some instruction may reside in links to other sites (e.g., references, related on-line courses). The system should provide for a face-to-face and/or e-mail component, supplied by an instructor, who may reside at one of the Army's schoolhouses. The instructor's function should involve answering questions about the material, facilitating deeper understanding of the material, and remediating any misconceptions of key points. The web-based software should reside on any Army-controlled server owned by any Army unit.

Anticipated Student Load

The student target audience should be any officer enrolled in one of the Army's training and/or educational facilities. Thus, the load may be high, since it could include both active duty and reserve officers of most ranks in the Army. Student load could be even higher if other educational institutions, such as West Point, chose to employ the training.

Alternative Instructional Strategies, Methods, And Media

Alternative instructional strategies, methods, and media should be considered. The instructional strategy should be designed to optimize student participation, student feedback, student pacing, and instructional sequence.

Support for Developing and Maintaining the System

To develop the system, the following resources are required. Access to tactical Subject Matter Experts and existing tactical and garrison scenarios used in current training are necessary. Army participation in overseeing/validating content development is also required. To conduct formative evaluations, it will also be necessary to obtain comments from students and/or instructors who participate in pilot tests of the system.

Facilities Requirements

Web hosting and maintenance are necessary to keep the training content up-to-date. We also assume that the classroom facilities will be available for delivering any face-to-face components of the training that are needed.

Evaluation and Assessment

Access to Army officers for formative assessments and to serve as control and experimental groups for outcome assessments is required.

Quality Improvement Metrics

Assessment should be based on development of a measurement paradigm and a set of measures of CT. The experience of Army SMEs/instructors should be utilized for validation of the measures. The measures should assess how the process of CT has improved among the cadre of officers taking the course. This assessment should distinguish CT process from CT products (outputs). The assessment should be focused not global. That is, it should be designed to assess the particular CTS that have been addressed by the training, rather than just CT as a whole.

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Additional Requirements

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The interviews with the ILE team members and the classroom observations yielded two additional requirements for $(CT)^2$. Both sets of data suggest that special consideration should be given to the population of adult learners for which training would be developed. Second, interview respondents favored a particular model of curriculum for adult learners, the Experiential Learning Model (ELM) (Kolb, 1984), which has been adopted by CGSC. Thus, two additional requirements for new CT training are that (1) factors that affect adult learners should be considered in the system's design, and (2) the ELM should serve to guide curriculum development. Factors that affect adult learning are discussed first, followed by a summary of ELM.

Needs of the Adult Learner

As stated in the functional requirements, the target audience for any military instruction is the *adult learner*. Wlodkowski (1993) defines this individual as one who performs social roles that our culture assigns to adults (e.g., citizens, soldiers), and perceives him or herself to be responsible for his/her life. In contrast to the public educational system, which was designed to instruct children, the adult learner has a number of needs that must be addressed regardless of whether learning takes place in a traditional classroom or a distance-learning environment.

In particular, adults need to know why they should learn what is being taught. This can be achieved through engaging introductory scenarios and realistic simulated experiences early in the lesson (Sacks, 1998). Adults also see themselves as self-directing, responsible for their own learning. Thus, trainers should give adult learners a choice of learning assignments to a sense of

control. Since adult learners come with experience, they will view their lessons negatively if they do not have an opportunity to capitalize on their background, which will likely be heterogeneous across the population of learners.

Adults are also highly pragmatic, life-centered learners who must see the relevance and immediacy of a task rather than simply learn for the sake of learning. They will also have a problem-centered orientation. They will learn best from those experiences that engage the senses, where the most effective learning begins with practice and ends with theory (Palloff & Pratt, 1999). Finally, adults are more responsive to internal motivators such as the desire for self-esteem. Yet, by the time learners become adults, fewer than one in five has a positive self-image about their ability to learn (Rose & Nicholl, 1998).

Within the larger population of adult learners are the demographics of younger students, who belong to a combination of Generation X (born between 1965 and 1976) and Generation Y (1977–1995). Military students fall into these demographics, and because of their heavy exposure to television and other media, they have high expectations for the quality of technology-based instruction they receive. In this regard, Sacks (1998) found that nearly half of the college students he surveyed chose entertainment as the most important characteristic of an instructor. Gen-Xers prefer fast-paced presentations and want their education combined with entertainment. They also want to receive frequent feedback, experience a daily sense of accomplishment, and have freedom in choosing their assignments and location where they study (Abell, 2000). In sum, the military instructional developer must consider a variety of factors when designing a distance learning curriculum, knowing that his/her Gen-X and Gen-Y adult learner students have special requirements.

For the reasons noted above, an additional functional requirement for new distance-based training in CT is that it considers the special needs and characteristics of the adult learning population.

Experiential Learning Model (ELM)

Our interviewees said that, in recognition of their adult student base, SCP and CGSC have adopted the ELM (Kolb, 1984) to provide overall guidance for the development of their instructional materials, particularly lesson plans. There are several reasons why the development of $(CT)^2$ should also use this model. First, instructional developers, instructors, and students are familiar with the model. Familiarity is likely to increase comprehension and encourage acceptance of new training materials. Second, the ELM is similar to instructional models that have been empirically shown to be effective for adult learners. Interviewees who used the ELM testified to its effectiveness. Thus, it appears to be a sound method that is likely to increase the effectiveness of new instruction. Third, the ELM includes features that are likely to increase student motivation, which is essential to any distance-based instruction. For these reasons, use of the ELM is considered a final functional requirement for new $(CT)^2$.

The six-step model, depicted in Figure 1, deviates from traditional methods of instruction by switching the order in which academic and practical information is presented. As shown in the figure, instruction begins with a concrete exercise designed to start everyone at the same

point. Next, intensive performance feedback is given to the student, where feedback comes from a mix of peers, instructors, and SMEs. The feedback is administered according to advanced instructional principles and it is where most learning is assumed to occur,
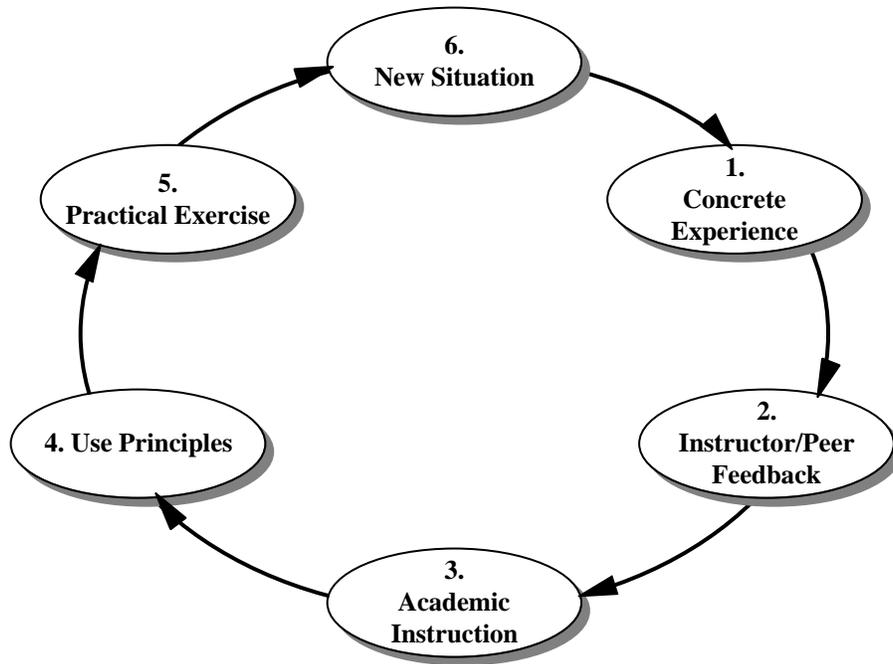
Figure 1. The six-step Experiential Learning Model (adapted from Kolb, 1984).

In Step 3, the students receive the bulk of their academic instruction, in which the principles underlying the task content of the exercises are presented. Abstract conceptualization is emphasized here, along with new information, theory, and techniques. During Step 4, students engage in a second round of concrete exercises, in which there are opportunities for active experimentation with alternative methods of implementing the principles just presented. In Step 5, students demonstrate competence by performing a practical exercise where formal grades and critiques are provided. Finally, the students encounter new situations to which these skills should transfer. Our Survey results suggest the ELM is presently receiving widespread recognition with the Army and, as such, will be a useful foundation for the curriculum development of $(CT)^2$.

COMPUTERIZED TRAINING IN CRITICAL THINKING

In this section, we describe a training system designed to increase the CT of Army officers. The system, Computerized Training of Critical Thinking or $(CT)^2$," delivers distance-based training via the Internet.

The design of $(CT)^2$ was guided by the results of a series of studies, reported in this document and elsewhere (e.g., Fischer, et al., 2008a; Fischer, et al., 2008b). The studies led to the identification of a set of pedagogical principles that served as the philosophical basis of $(CT)^2$'s design. Practical considerations and the functional requirements previously discussed also influenced the design of $(CT)^2$. A discussion of the guiding pedagogical principles and a description of the training system are provided below.

Pedagogical Principles

The following paragraphs describe each principle, how it was derived, and the training system design characteristics it suggests.

CT Skills Can Be Learned, Trained, and Transferred

The model of CT presented in Volume Two of this report posits that CT in general can be facilitated and enhanced by developing specific skills and that these skills can be learned and trained. This is a fundamental assumption about the nature of CT that leads to other assumptions. First, current thinking about skill acquisition posits that it develops over time under the right conditions. While skill performance may be affected by inherited traits or abilities, it is generally assumed that everyone with normal cognitive capacity can develop some degree of proficiency in executing skills that support CT. If these skills are learnable, then it should be possible to develop a training system that improves performance. Second, research has identified some of the conditions that are necessary to skill development, including practice, assessment, and feedback. Third, the conditions of training will affect the degree to which performance of any skill transfers to real world situations (Halpern, 2004).

Practice is Essential. It is commonly accepted that all skill development requires practice. Moreover, the idea that skills that support CT can be improved with conscious, deliberate, practice is posited by many theorists (e.g., Paul & Elder, 2001). Said another way, skill performance does not improve with an increase in content knowledge alone. It is one thing to understand how to create topspin on a tennis serve; it is another to actually do so. The latter requires repeated attempts to create such a serve. Practice is critical to skill development whether the skill in question is psychomotor or cognitive. For example, the comprehension that is obtained by reading math text only goes so far in developing the ability to perform math calculations or applying the correct equation to a calculus problem. Practice at performing calculations or applying a formula is essential to developing these proficiencies. Therefore, the first pedagogical principle that guided the development of $(CT)^2$ was that the system should include practice at performing CT skills. Thus, each $(CT)^2$ module contains practice exercises that require students to practice CT skills.

Feedback is Essential. An axiom of skill acquisition is that feedback about performance is required (Kluger & DeNisi, 1996). The learner cannot modify his/her performance without knowing whether, and what kind of, changes are needed. Simply, learning will not occur in the absence of feedback. Moreover, if external feedback is not provided in a learning situation, the student will very often supply his/her own feedback, evaluating performance based on idiosyncratic standards that may or may not be appropriate. Psychological science also shows that immediate feedback is more effective than delayed feedback. Therefore, another pedagogical principle that was adopted was that feedback should be provided to students immediately following each decision or action. Hence, descriptive feedback is given for each response students make when using $(CT)^2$.

Assessment is Essential. It is impossible to include feedback in the absence of assessment. The evaluation of student performance during training is essential so that informative feedback can be provided as students practice a skill. In $(CT)^2$, students' knowledge and skill development are assessed following each major lesson of the training to give them, and their instructors, an understanding of where they stand in the learning curve. The assessment measures can also be used before taking any portion of the training to determine whether or not the training is appropriate for the student.

Training Conditions Should Optimize Transfer. Research has shown that leading students toward perfect performance in the context of training does not ensure that that performance quality will transfer to real-world situations. Although the findings are non-intuitive, transfer is decreased by mastery learning requirements in training. Perhaps perfected skills do not transfer well to real world applications because situational conditions in the classroom never match the complexity of real-world situational variables. Thus, mastery learning conditions lead to the development of inflexible skills that cannot be applied to unfamiliar situations. If learners practice skills in a variety of contexts, those skills are more apt to generalize to unfamiliar contexts (Halpern, 2004). $(CT)^2$ was designed to optimize transfer, as opposed to optimizing performance in the context of training.

Part-Training Methods are Most Effective

Well-honed CT is essential to good performance in many kinds of battle command tasks and situations (Fischer, et al., 2008a). However, to organize a CT training program around such real-world tasks or situations would be inefficient because a considerable amount of time would be spent on issues unrelated to CT. A training system that taught CT by having students perform large-scale battle command tasks would also be less effective at developing CT because the focus of the system would be too broad. Therefore, $(CT)^2$ provides students with instruction and practice on only those parts of real world battle command tasks that demand CT resources, but not the whole task. (CT^2) focuses on a set of important component, critical thinking skills. It was necessary to adopt a reasoned strategy for determining which critical thinking skills would be the focus of $(CT)^2$. Two pedagogical principles were adopted to create the desired focus of the training. The first principle identifies the kinds of critical thinking skills on which the training should focus. The second identifies the subtasks that should be emphasized by the training.

Focus on important and problematic critical thinking skills. Some training programs, both military and civilian, attempt to teach CT in the context of critical thinking skills that have been haphazardly selected. Instructors or curriculum developers may fail to systematically identify the critical thinking skills that would benefit most from CT training. For example, CTS may be selected because they are discussed as critical components of CT and are recommended in popular philosophy books and texts. Without a reasoned, systematic selection method, the effectiveness of the resulting training program is questionable. There are many critical thinking skills on which the training might be focused (See Appendix A for a detailed list). Moreover, a reasonable assumption is that Army officers already perform many CTS well. To assume that officers need to be trained on all possible tasks is a mistake. Therefore, another pedagogical principle that guided system design was that *training should focus on development of critical thinking skills that have been documented to be important and problematic to battle command.*

Research, reported in Volume Two of this series and shown in Appendix C, identified eight critical thinking skills that meet these requirements. The prototype (CT)^2**,** described in this volume, focused on, and was organized around, two of the eight critical thinking skills previously identified as important and problematic to Army battle command.

Focus on common and consequential errors. The performance of complex critical thinking skills can be broken down into sub-skills, just as physical tasks can. For example, when serving, tennis players must be able to position themselves at the right place on the court, grasp the ball and racket, position the racket correctly in their hand, toss the ball to the right height and location, position the racket behind their arched back, swing to make contact with the ball, and follow through with the racket face angled in the right direction to create topspin. Similarly, critical thinking skills, such as *Framing the Message,* require the ability to read or hear the message, understand the meaning of each word, comprehend each sentence, relate each sentence to the other sentences, and form a mental structure that represents the message. Some subtasks serve the purpose of supporting others, which may be referred to as enabling subtasks.

Training enabling subtasks of a complex critical thinking skill would be inefficient and unnecessary, as it is likely that students are already perform them well. For example, it would be a waste of time to teach reading skills to Army officers in an attempt to improve their ability to *Frame the Message*. Moreover, enabling subtasks typically do not greatly contribute to overall performance of a skill. They may be performed well by all members of the target population, or they may simply not be very important to overall performance of the task. In summary, training unimportant subtasks is a waste of everyone's time and is costly.

If we assume that it is unnecessary and inefficient to teach enabling subtasks, then on what subtasks should the training focus? One answer is to determine where training is most needed, and then focus training on those problematic areas. One clear indicator of the need for training is error, especially if that error is common and if the consequences of that error are severe. Investigations reported in Volume Two of this report were helpful in identifying errors commonly made and associated with particular critical thinking skills important and problematic to Army battle command. Hence, the second pedagogical principle adopted to guide design of (CT)^2 was that *the training should focus on those critical thinking skills and subtasks that*

commonly produce consequential errors. Therefore, the content of (CT)**2** addressed those errors that Army officers had reported as common to battle command tasks they have to perform.

Use Training Methods Appropriate for Adults (Army Officers)

As stated in the functional requirements, the training should target the adult population of Army officers. Training developed for adults should take into account the unique characteristics and needs of the population. The relevance and importance of the training should be apparent. Adult students should be informed of why they should learn what is being taught. Because adults are accustomed to directing their own activity, they should be given control over their own learning whenever possible. Adults' motivation will be highly affected by factors that influence their self-esteem. Thus, feedback is particularly important. To address the needs of the adult student population, several pedagogical principles were adopted to guide development of (CT)**2**.

Use concrete experience to start. The adult learner needs to be convinced at the outset of the training that it is worth the effort to participate. Ensuring their engagement in the training can be accomplished in many ways. The ELM, (Kolb, 1984),, which is used by several military training programs, employs a concrete experience in the beginning of the training to bring the adult student to the table, peak interest, and convince the student that the training may be useful. The effectiveness of the concrete experience, however, varies with the particular experience and course. It is necessary to make the concrete experience highly relevant and engaging. Hence, one principle that was used throughout development of (CT)^2 was that a *concrete experience should be given at the beginning of every major section of the training*. Each major lesson of (CT)^2 includes a concrete experience in the form of a realistic and engaging scenario that describes a particular error that is commonly made and is associated with the critical thinking skill or subtask being taught.

Base the training on realistic scenarios. To convince adult students that the training is relevant and important to their work, it is important to explicitly relate the training to a familiar context. Realistic scenarios are one way to put the adult in a familiar situation, task, and problem and can be highly effective in convincing adult students that the training is worth their while. In addition, it greatly increases the likelihood that these skills will later transfer to, or be applied, in the real world. Moreover, the CT model discussed in Volume Two of this report states that CT is stimulus-driven. According to the model, it cannot occur in the absence of real-world stimuli in which CT can and should be applied. The richer and more realistic the scenario, the more likely students are to be engaged and to buy into the exercises. Thus, another pedagogical principle adopted was that the *training should provide multiple, rich scenarios that contain problems for which CT can be applied.* (CT)^2 is organized around such scenarios.

Make training increasingly complex and difficult. To maintain the motivation of the adult learner throughout the training, it is important to keep him/her challenged. Instruction should begin at a level at which the student can successfully build and reinforce key foundational skills, then move on to refine and build upon those skills so they can be applied in increasingly more complex situations. The real world requires the execution of many complex critical thinking skills that are associated with common errors. Additional instruction is needed only for complex critical thinking skills. Hence, the following pedagogical principle was adopted. While

the *training can begin with simple scenarios and exercises, the complexity and difficulty must increase as the student progresses through the program.* Scenarios should grow in complexity throughout the curriculum, reflecting the expected increases in skilled performance.

Training should be Distance-based

As stated previously, the training was designed to be widely distributed via the Internet. Distance learning poses additional challenges to the curriculum developer, who must take into account problems with maintaining student motivation. The biggest factor that determines success in distance learning courses is student motivation. Thus, it is important to include motivation-enhancing elements in any distance-based training, especially when that training is CBT or WBT. Four pedagogical principles were identified to ensure that the training would encourage motivation.

Multimedia is essential. If CT could be readily obtained from pure reading, the best media for delivering that training would be textbooks, which are portable and easier on the eyes than computer screens. Moreover, in the real world, CT is applied to many different forms of material such as graphics, text, audio, film, direct observation, tables, etc. Hence, a variety of instructional media and formats should be used in the training. Computers offer functionality that cannot be obtained from textbooks. Specifically, computers offer multimedia capabilities that include audio, film, animation, and graphics. Furthermore, presenting material in a variety of formats also tends to encourage motivation (Mayer, 2001). Thus, the *training should capitalize on the multimedia capabilities that WBT offers*.

While acknowledging the importance of multimedia presentation, it is important that the primary purpose of the proposed training be guided by pedagogical principles and not the "bells and whistles" of the latest technology. While multimedia will tend to make the training more usable, it should never lead the training away from its central purpose, which is to further develop CT skills. Therefore, $(CT)^2$ was designed to balance the motivational and entertaining benefits of multimedia technology with its driving purpose.

Interactivity is essential. Requiring students to actively interact with the program, rather than merely read through information on a computer screen, will also increase motivation and decrease dropout rates (Mayer, 2001). While physical interactivity on WBT may be limited to clicking, typing text, scrolling, and dragging and dropping, cognitive interactivity is limitless. Hence, to the degree possible, *interactivity should be an integral component of the WBT in CT*. $(CT)^2$ includes interactivity that supports the overall objective of increasing CT.

Use scoring. Adults respond well to and are highly motivated by feedback about their performance. (Kluger & DeNisi, 1996). One of the clearest ways to provide feedback is to provide a score. In this case, points are earned and lost based on performance. Therefore, another motivating tool that should be included is scoring of performance. However, both interactivity and scoring should not be overdone such that the training becomes video game-like. $(CT)^2$ provides scoring when appropriate under the condition that the scoring supports the overall objective of increasing CT.

Use innovative training techniques. Research suggests that one of the best means to increase CT capability is the application of one-on-one Socratic training. The effective component of the Socratic method is the unveiling of the student's invalid assumptions, deductions, inferences, and generally, reasoning. Distance learning, specifically WBT, makes the ideal of one-on-one Socratic training impossible to achieve with existing technology. It may, however, be possible to provide WBT that also targets the student's poor reasoning. To do so requires innovative training techniques where students perform exercises requiring that they critically think and reveal their reasoning. As previously discussed, feedback pertinent to each critical action is necessary, as previously discussed. Therefore, the training *should include innovative training techniques that require students to apply CT to a critical thinking skill and then receive feedback.* (CT)^2 was designed around innovative training techniques that permit the provision of feedback.

Course Overview

The web-based prototype (CT)^2 trains two CTS modules: CTS 1. Frame the Message and CTS 2. Identify the Gist in a Message. A description of training for these two modules is given in this section.

Course Objectives

The focus of the (CT)^2 training program is to improve key skills that support critical thinking and thus help Army personnel process information more effectively and efficiently. Critical thinking involves a deliberate, systematic awareness of the process and products of one's own thinking. This is especially important in a military setting where personnel are required to interpret, analyze, integrate, evaluate, and remember information that comes from a variety of sources and in a variety of formats, such as text, audio transmissions, diagrams, tables, pictures, video, and so on. This training program focuses on targeting common – and potentially serious – errors that people make when they don't apply appropriate critical thinking skills. These errors include overlooking important details, misinterpreting information, and making incorrect assumptions – all of which can lead to poor decision-making. The training program highlights awareness of these errors and teaches specific techniques that can help people overcome them. It presents the student with real-world situations and asks them to complete numerous thinking exercises that require the practice and application of CT in a variety of realistic settings.

For CTS 1, by the end of the training program students should be able to: (1) identify key components of a message and the relationship between them; (2) generate appropriate inferences and recognize inappropriate ones; (3) identify weak (i.e., unclear or questionable) parts of a message and be able to apply the appropriate steps to resolve these weaknesses; and (4) use techniques to help them better remember, analyze, and evaluate key information. Objectives for CTS 2 are similarly specified.

Target Student Population

(CT)^2 was designed for Army personnel in leadership positions, although all personnel could benefit from the training. In order to make the training as meaningful as possible, realistic

Army messages and situations were employed; therefore, before beginning the training program, students should have some Army training and experience. They should be familiar with Army terminology, acronyms, and standard report formats. They should, for example, be able to understand standard Army messages such as task organization tables, operation orders, mission statements, and battlefield sketches. (CT)^2 assumes students already have some domain knowledge; it gives them practice in applying strategies to use that knowledge more effectively.

Overview of (CT)^2 Format

As Figure 2 illustrates, (CT)^2 is divided into three sections: an introduction to the general topic of CT, followed by two main modules that focus on particular critical thinking skills. The Introduction highlights the importance of developing critical thinking skills and outlines the organization and methods used in the course. The first module focuses on the critical thinking skill of framing a message, and the second focuses on extracting the main gist of messages.

Each module comprises a series of elements or lessons designed to help students develop specific techniques that will help them interpret and critically perform the critical thinking skill in question more effectively. Specifically, each element provides training that is designed to reduce one or more common errors associated with the critical thinking skill. The elements within each module build on each other, beginning with foundational concepts and moving on to increasingly more complex and sophisticated material. This ensures that students are successfully able to master, apply, and refine a skill before advancing to the next one.
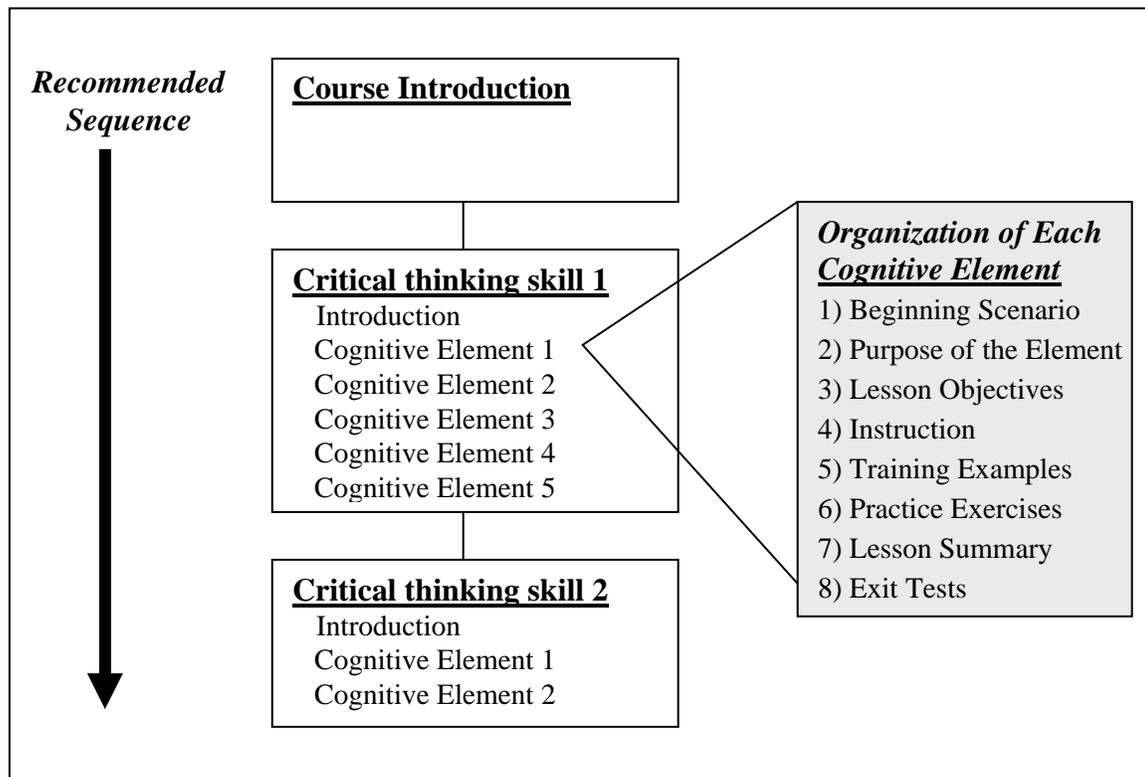
Figure 2. (CT)^2 course format.

Module Format

Each module is self-contained, and presents training pertinent to a single particular critical thinking skill. Although we strongly recommend that students progress through the modules in the suggested sequence, it is possible for an instructor to assign students to individual modules only or to modules in a different sequence than is recommended. The material and exercises within a particular module do not assume that the student has completed prior modules. Each module focuses on errors associated with a particular CTS.

Organization and Content of Modules

Each module begins with an introduction to the particular critical thinking skill targeted by the module. The introduction section of the module opens with a concrete scenario illustrating the importance of the task and the errors that can result when it is not performed well. It then goes on to provide a clear definition of the critical thinking skill, as well as key concepts and terms and a brief explanation of how this cognitive task relates to CT. This is followed by concrete examples illustrating the key concepts. The introduction section concludes with an outline of the main objectives of the module and a plan for how the objectives will be trained.

The next section of each module consists of two to five sub-modules called *Cognitive Elements*. Each Element targets a common error associated with the critical thinking skill.

Element Format

Each of the elements targets a specific CT error and focuses on techniques that one can use to develop awareness of where, when, how, and why critical thinking skills should be applied. As shown in Figure 2, each element contains the following sections:

1. An opening scenario that illustrates the importance and prevalence of the CT error covered in the element
2. Main Purpose of the element
3. Specific Lesson Objectives
4. Instruction providing content information, rationale, and practical applications
5. Training Examples
6. Practice Exercises
7. Summary of main point of the lesson, practical considerations and applications
8. Exit Tests

This format is consistent with well-established lesson design principles, such as those used in the Experiential Learning Model and Direct Instruction Model (also known as the Madeline Hunter Method (Hunter, 1984)). The elements are based on clearly specified objectives that outline the purpose and goals of the exercises. The scenarios that begin each element provide an

anticipatory set, or "hook," that not only grabs the students' attention, but also gets them ready to learn the material by providing them with a concrete situation that they can relate to and use to organize the information. Many of the scenarios also provide a means of confronting students with their own biases and tendencies to make the errors that are targeted in the lesson—again, making the material more relevant and motivating for the students.

The instruction following the scenarios is designed to encourage students to develop their own meaningful understanding of the material through concise explanations interspersed with numerous examples and practice exercises. The examples used mainly involve a variety of military scenarios, in order to promote transfer. The exercise format generally takes a scaffold approach, with more structured guidance during the initial exercises and less so during the latter ones. The exercises themselves involve as much interactivity as possible, requiring students to actively apply the skills and techniques they just learned. This approach requires students to engage with the material, connect it to their prior knowledge, and to make sense of it. Each exercise also provides as much feedback as the web-based format allows. Some exercises provide immediate direct feedback (e.g., "correct" or "wrong") while others have students compare their responses to an expert's. Many of the exercises provide practice for the exit tests given at the end of each element.

Assessment Format

The tests at the end of each element provide reinforcement of the material and inform the student and the instructor about the extent to which the student achieved the element lesson objectives. The series of tests generally follow the format outlined in Table 1.

Table 1. End of Element Exit Tests

Test	Purpose	Question Type
Knowledge Test	Designed to measure how well students learned concepts and terms	Consists of multiple choice questions on content covered in the element
Knowledge Application Test	Designed to measure how well students can apply the concepts and techniques learned in the element	Consists of a brief scenario, message, or other stimulus followed by multiple choice questions
Skill Application Test	Designed to test how well students can apply skills and concepts in a realistic context	Generally follows the same type and format as the training exercises, but is more challenging

All tests are designed using the best practices of test construction, and are graded by the computer—that is, they do not require the instructor to do the grading.

Access to Course

Students are assigned a password from the course administrator. Only students who have a password are able to log on to the program. The program keeps track of the last page students accessed and brings them to that page when they next log on. It also records responses to test items and makes the responses and scores available to instructors.

Course Syllabus

Course Content and Organization

The course is organized in the following manner.

Course Introduction. The course introduction provides a brief overview of CT, explaining what it is and why it's important, and outlining how the course is organized.

Critical Thinking Skill 1: Frame the Message. The first module provides instruction on the critical thinking skill, *Frame the Message*. It is designed to promote the ability to identify the essential elements of a message, understand the relationships among them, and describe a high-fidelity representation of the message. It addresses common battle command problems such as difficulty in establishing clear and accurate understanding *of* a commander's intent statement and difficulty in *conveying* clear intent. The main learning objectives of this module are: developing awareness of message structure in order to better interpret, evaluate, critique, and remember key information; and recognizing potential biases in interpreting information. The Cognitive Elements that comprise this module, the likely errors addressed by each of the Elements, and the training methods that target these errors are outlined in Table 2.

Table 2. Elements of Critical Thinking Skill 1: Frame the Message

Element	Known and/or Likely Error(s)	Training Methods that Target Errors
#1: Identify a Frame for a Structured Message	1. Select wrong frame for message 2. Fail to place information in frame slot 3. Incorrectly place information in slot	1. Provide instruction on frames and messages 2. Provide instruction and practice with feedback in selecting frames for structured messages 3. Provide instruction and practice with feedback in classifying structured message elements in frame slots
#2: Analyze an Unstructured Message	1. Fail to place ALL information in slot 2. Incorrectly place information in slot	1. Provide instruction on a multi-use frame for use with unstructured messages 2. Provide instruction and practice in classifying ALL unstructured message elements in multi-use frame slots
#3: Identify Weak Spots in a Message	1. Fail to identify or recognize weak spots 2. Fail to identify reason for, and thus, cannot resolve weakness	1. Provide instruction on 6 reasons why a message element may be weak 2. Provide instruction and practice in distinguishing between unclear and uncertain weak spots 3. Provide instruction and practice in identifying weak spots and why they are weak
#4: Resolve Weak Spots	1. Fail to resolve weak spots. Hence, frame contains missing information, uncertain, or unclear information	1. Provide additional practice in identifying reasons for weakness 2. Provide instruction and practice in ways to resolve weak spots specific to their source of weakness
#5: Critical Self-Assessment	1. Makes unjustified inferences in a number of ways. For example: (a) Substitute what a message should say for what it does say, (b) Interpret content of message to fit preconceived notions, (c) Believe that own inferences are given as evidence in message. 2. Fail to recognize probability that inference is correct, or incorrect	1. Provide instruction on assumptions and inferences 2. Provide instruction on levels of justification for inferences 3. Provide instruction and practice in using multi-use frame to reveal inferences (e.g., assumptions)

Critical Thinking Skill 2: Recognize Gist in Material. The second module provides instruction in the CTS, *Recognize Gist in Material.* It is designed to promote the ability to sort through the details in a message (written, graphical, visual, auditory, and/or tabular) and extract the gist therein. It addresses common battle command problems such as filtering overly-detailed operation orders in order to write clear and concise mission statements that capture the gist of the original message, and reducing the amount of time that time-pressed lower echelons have to spend on accurately extracting the essence of a mission. The main learning objectives of this module are: representing the essential points of a message in a clear, concise manner; and recognizing how the process of distilling the main idea encourages deeper processing and can lead to increased ability to remember, evaluate, and use the information. The Cognitive Elements that comprise this module, the likely errors addressed by each of the Elements, and the training methods that target these errors are outlined in Table 3.

Table 3. Elements of Critical Thinking Skill 2: Recognize Gist in Material

Element	Known and/or Likely Error(s)	Training Methods that Target Errors
#1 Extract gist from a message	1. Fail to eliminate details from central meaning of message	1. Provide instruction on removing details from message.
#2 Find the anchor points in a message	1. Select incorrect main points of message	1. Provide instruction on anchor points, or main points of message. 2. Provide instruction and practice on selecting key anchor points, iteratively whittling message down from 12 to 8 to 4 elements that best capture its central meaning.

Recommended Sequence of Training

We strongly recommend that students progress through the training in sequence, beginning with the introduction, moving on to Critical Thinking Skill 1, Critical Thinking Skill 2, and so on. However, the course has been designed so that each critical thinking skill can function as a stand-alone module. Because the elements within each critical thinking skill build on each other and some elements refer to concepts and activities in elements covered earlier within that critical thinking skill, students will be required to complete the elements within each critical thinking skill in order.

Instructor's Role

The course is designed to function as a stand-alone program and can be completed with minimal instructor involvement; however, instructors can augment the material by facilitating discussions, providing additional real-world examples, and by providing additional activities to reinforce and/or supplement the material covered in the course. Likewise, the course itself can be used to augment or supplement existing critical thinking and other related courses.

Suggested Implementation

The course can be used in a classroom setting, as supplemental exercises completed outside of class, or it can be used as a distance-learning course.

Estimated Time to Complete the Course

Each element is designed to take approximately 1.5 to 2 hours to work through the content information and do the practice training exercises. The Exit test is designed to take approximately 20 minutes. Table 4 outlines the estimated time to complete each prototype module.

The expanded version of $(CT)^2$ contains training modules for eight CTS. The standard training module for each CTS takes about two hours to complete. In addition, the first four skills each have an extended training module which takes about ten hours to complete per skill, as do the prototype training modules.

Table 4. Estimated Time to Complete Sections of the Prototype Course

Section of Course	Approximate Time To Complete
Course Introduction	.5 hours
Critical thinking skill 1	10-13 hours
Critical thinking skill 2	4-5 hours
Total time	*15*-20 hours

EVALUATION OF (CT)^2

In this section of the report, we describe an investigation that was conducted to evaluate the effectiveness, usability, and student acceptance of the (CT)^2 prototype. The objective of the investigation was to determine whether (CT)^2 effectively increases measurable indicators of CT compared to two other learning conditions. The research also assessed participating students' attitudes and subjective evaluations of (CT)^2 as indicators of acceptance and usability.

Method

Participants

Nineteen soldiers (17 males and 2 females) from the 3rd Brigade of the 85th Reserves Training Division volunteered to participate in the research. Eligible members of the Division were made aware of the opportunity in their monthly meeting held by the 85th Reserve Division. Potential participants were given a briefing describing the purposes and procedure of the research. Following the briefing, they were requested to indicate their willingness to participate by providing their name, email address, and phone number on a signup sheet. At that point, volunteers were given an informed consent document to read and sign as well as a brief demographic survey.

Because (CT)^2 was designed for Army officers and senior enlisted personnel, participation in the research was limited to those individuals with a rank of E5 to O6. Three Captains, six Majors, six Lieutenant Colonels, two Colonels, one 1st Sergeant, and one Master Sergeant participated in the research.

Upon completing the research, all participants received (1) a certificate of achievement issued by their commanding officer, and (2) a $75 check that was made out to the unit's family support group.

Materials

Participants were randomly assigned to one of three CT training conditions. They either received web-based training in one CT module of (CT)^2, completed distance-based coursework modeled after an existing CT class offered at CGSC, or received no training beyond what they had already been given as Reserve Army officers. All participants were first asked to complete a demographic questionnaire that gathered information about their rank, job position, and gender. Different sets of instructional materials were developed and delivered to participants depending on the condition to which they were assigned.

Materials for (CT)^2 group. Participants assigned to the (CT)^2 group were exposed only to training materials provided by the web-based training. Specifically, they were instructed to read the material on the first page of the website, register as a student, read the introduction to CT, and work through all the readings and exercises for the first critical thinking skill covered by (CT)^2, *Frame the Message*. A description of the material covered in this critical thinking skill is given in Section Four of this report.

Materials for the distance-based simulated CGSC group. The alternative training group was provided with written instructions, reading assignments, and written exercises. The reading assignments covered a description of critical thinking elements as developed and described by Paul and his colleagues (Paul, et al. 1990; Paul, 1995; Paul & Elder, 2001). The exercises asked them to critically review substantive, controversial materials that were relevant to national security and therefore to the strategic environment in which they operated. The critical reviews required the participants to use Paul's elements and standards of CT as criteria for their evaluation. Each participant was provided feedback on his or her responses.

Assessment instrument. To determine the relative effectiveness of the three conditions at encouraging CT, an assessment instrument was developed and administered to all participants at the end of the research. The assessment instrument was designed to measure the degree to which an individual used CT in answering a series of questions about four different messages.

The four messages were selected for relevance and interest. The first was a web page graphic that described the NCO Vision as provided by Sergeant Major of the Army, Jack L. Tilley. Message #2 was an Army Directive, a one-page letter, from the Secretary of the Army, Thomas E. White. The third message was a one-page statement published by Al-Qaeda on the Internet. The final and fourth message was a one-page extract of President Bush's National Security Strategy, published a few months after September 11, 2001.

Following each message were three sets of questions, organized in three corresponding sections. The first section contained several questions that assessed participants' memory for the material contained in the message. The memory questions elicited the recall of particular components of the relevant message. Section Two contained several questions, each of which asked the participant to interpret the message. The interpretation questions asked for information that was not explicitly contained in the message, but could be derived from the message's content. Participants were instructed to use their experience and judgment to answer the interpretation questions. They were also told to justify their responses, and they were allowed to refer back to the relevant message. Section Three asked the participant to evaluate the message. The questions in the evaluation section asked participants to judge the quality of the message, whether the message was effective, and whether there were any parts of the message that were weak, illogical, not believable, etc.

Each assessment package was labeled at the top with a single participant control number to ensure confidentiality of responses. The control number ensured that participants' names could not be associated with the responses. The number also afforded grading of the responses that was blind to the participants' group assignments.

The assessment package for the participants assigned to the $(CT)^2$ training condition also contained a user acceptance section. The user acceptance section contained questions concerning participants' evaluation of the training. It elicited their general evaluation of $(CT)^2$ as well as their reactions to the length of time it required, its effectiveness at promoting learning, and its relevance to their work. It also elicited their recommendations for the web-based training system.

Procedure

After control numbers were assigned, the participants were randomly assigned to the three conditions of the experiment. This insured that a sequence of numbers would not give any clue as to who was assigned to which group.

Six individuals were instructed to access and complete the training material for one module of the web-based critical thinking training program. Five participants who were assigned to the distance-based simulated CGSC group were given the readings and assignment materials previously discussed. The final group of eight participants served as a control group and did not receive any additional training.

Procedure for (CT)^2 training condition. Participants assigned to the (CT)^2 condition were sent e-mail messages that contained instructions, the Internet address to (CT)^2, and a password that gave them access to the training program. They were instructed to go to the given Internet address, register as a student, and begin the training program. Once registered as a student in (CT)^2, the program directs all further training and is essentially self-contained. (CT)^2 is self-paced and self-directed such that very little or no administrative activities are required of an instructor or administrator. The program incorporates immediate feedback for each exercise it contains. It also documents the results of intermediate assessments as part of the training. In this investigation, students' progress was monitored by periodically checking the data files to ensure that they were completed in a timely fashion.

Procedure for distance-based simulated CGSC group. The training that was modeled after a CT course offered by CGSC that was also distance-based. However, this training was entirely administered via e-mail. Students were given two assignments. The first assignment was delivered with the first e-mail message sent to participants in this group. Attached to the email were four files. Participants in the alternative training condition were instructed to read an essay, described previously, contained in the first file. Then they were asked to review a quick reference guide. Third, they were told to view a PowerPoint slide that contained a lesson on the general topic of CT consistent with Paul's and Elder's text book. Once the student believed that they understood the materials, they were instructed to open the last file, which contained questions on the essay and CT lecture. They were asked to answer the questions in the boxes provided in the document. When they were finished answering the questions, which constituted the first exercise, they were told to save the file, and return it to an experimenter.

Students were sent to the second exercise when they returned the first assignment, Two folders were sent to them. The first contained written feedback concerning their responses to the first assignment. The other contained information they needed for the second assignment. They were told to find two documents in the second file. One document was, again, an essay they were asked to read and evaluate. The second document was an analysis guide that contained a series of questions and written assignments. Students were instructed to complete the analysis guide and return it to an experimenter. Upon completing the second assignment, the alternative training was finished. Participants were sent feedback concerning their work on assignment #2. They were also informed that they would next take a test on critical thinking and were admonished to not discuss the training with their fellow participants. Through the alternative distance-based

training, participants were encouraged to ask questions and to contact an experimenter by e-mail or by phone. The progress of individuals assigned to this group was monitored to ensure that they adequately completed the assignments.

To ensure that the control group received a roughly equivalent amount of interaction with the experimenters during the training period, periodic updates about the progress of the research were emailed to them.

Participants who were assigned to either training condition had two months to complete their program. At the end of the prescribed training period, all three groups were administered the assessment instrument described previously.

Assessment procedures. The test was administered to participants during one of the monthly brigade meetings. Following general instructions concerning the assessment procedure, participants were provided with the first message to critically review. They were permitted to take notes on the paper on which the message was printed. Participants were instructed to return the message and any notes made about the message to the test proctor when they had finished review of the first message. The proctor then issued the memory, interpretation, and evaluation questions for that message. This procedure was repeated for the remaining three messages.

No time limits were set for completion of the assessment instrument. The fastest time that a participant finished was just under two hours. The longest time was about four hours.

Results

The results presented in this section are organized by the two broad questions the research was designed to answer. First, the research assessed user acceptance and usability by eliciting participants' attitudes and opinions about $(CT)^2$. Thus, we first discuss the responses of six individuals who participated in the web-based training to questions about course length, course relevance, acceptance, perceived learning benefit, and recommendations. The results of a similar user acceptance survey of the distance-based course modeled after the CGSC course are also given to afford a comparison of the two educational methods. Second, the research assessed the relative CT performance of the three training groups to determine if $(CT)^2$ provide additional benefits not attainable by current CT training. The second half of the results section describes how well the three groups did on the final assessment instrument.

User Acceptance of $(CT)^2$

Length of training. Participants reported spending an average of 13 hours to complete the single module of $(CT)^2$, which included the introductory sections to CT, the introduction to the module, and the module's five elements. However, the time devoted to the training varied considerably. Several participants completed the work between 10 and 15 hours. However, one participant was able to complete the training in 6 hours while one reported that it took him 18 hours. Despite the considerable investment in time, each also reported that it was an appropriate amount of time to spend; the training was neither too long nor too short.

Several participants reported that the self-paced aspect of (CT)^2 allowed them to work on the training over several sessions, usually lasting one to two hours. Because it was self-paced, it did not seem excessively long. The material was substantive and interesting to hold their attention for the time it took to complete the training. However, they also reported that they would not have wanted to spend more than 2 hours in any one session. They uniformly appreciated the self-paced feature of the training, remarking that some sections required more study than others. The self-paced feature allowed them to review the more difficult concepts.

Relevance. Each of the participants reported that the material was highly relevant to their work, both in the civilian and military sectors. Several noted that they had experienced situations during and after the training in which they had applied what they had learned. For example, one instructor remarked that he had used the training to refine lectures and materials used in his class. Another reported that he had used it to analyze a multitude of email messages he received in his civilian work, and refine those he sent as well. In his particular civilian job, his coworkers were distributed throughout the world such that issues were resolved in series of messages, typically e-mail, but sometimes phone. He reported that the training helped him to resolve several issues and probably helped him avoid several potential problems. One reported that the training could be applied to combat arms or service support to understand information that one is given by others. He noted that everyone takes short cuts in understanding messages, and that the training helped him to avoid some of those short cuts. Another thought it was especially relevant to the staff environment where it could be applied to messages used in daily tasks and requirements.

General evaluation. All participants reported that they found the training interesting. Participants distinguished interest from enjoyment, however, reporting that they found it interesting but not necessarily enjoyable. One thought it would enhance his military and civilian career, and for that reason saw value in the training. Several commented that it was professionally interesting. The self-paced aspect of the training was reported to be beneficial in maintaining interest.

The audio features of the training were found to be particularly useful. Participants thought the audio portions made them approach a message a little differently than it if were written in text form alone. They also liked the realism provided by the audio and thought it helped to keep them interested and focused. One commented that the audio afforded the perception of the speaker's emotion, which gave him a different perspective from which he could understand the message. However, several participants wanted the option of skipping the audio portions because the large audio files took a little more time to load than did the simple text.

Participants liked the fact that the training was incremental and each element built on the previous element. The logical sequence was well received. The interactivity provided by the training was also appreciated.

Several participants reported that the inability to review material they had previously studied was a problem with the training. Because the training is self-paced, they reported that it was sometimes several days before they would get back to the training. At these points, they would have liked to review the previous material before moving on. However, the training, as was designed, prohibited use of the web browser's back button, and there was no way for users

to review materials. Other participants remarked that within a session, they wanted to go back and review materials but were unable to do so.

Several participants who used modified web browsers also experienced difficulty with the audio files incorporated into the training. One participant experienced occasional "hiccups" when loading pages and needed to either re-load the page or come back to the training at a later time.

The participants would uniformly recommend the training to their colleagues and subordinates. One remarked that the training was appropriate for any soldier who would be in a leadership position. One thought the training should be provided early in an officer's career. Others thought that the training was appropriate for all ranks. Several of the participants were instructors in their civilian and military jobs. Those individuals thought they would use the training as preparation for other training. As instructors, they would direct their students to go to the web site and complete a set of elements in preparation for other course work. They liked the distance learning aspect of the web-based training and would much rather use web–based training than training provided on a CD.

Self-reported learning. Participants reported that they thought the training had a positive impact on their thinking skills. They believed the training had to have an impact because it identified and reinforced the need for careful message framing and analysis. One thought it was helpful, but like anything else, additional practice was necessary to see the most benefit from the training. The skill must be applied routinely, or it will not develop. Another reported that it made him realize that what he writes or says must be clear to avoid misunderstandings from his audience. One reported that he learned the most from the sections that required him to analyze messages into their components.

Recommendations. Participants had several recommendations to improve the training. The one most frequently cited was to include the ability to review previously learned material. One participant wanted to see a greater variety of examples and others called for more audio messages.

Participants said the examples and explanation provided by the training were usually clear, but several portions would benefit from improved clarity. One participant thought that the training was aimed at the management or business class. He thought that the terminology and written material might be too high for someone at say, an NCO's level. Vocabulary that is more common might improve the training.

The inclusion of scoring systems in some elements received mixed reviews. On the one hand, participants thought that the scores made them pay closer attention and work harder. Scoring served as motivators, which was its original purpose. However, participants complained about some of the scores they received, especially when the system failed to give them points for an answer that they considered correct. That is not to say that participants generally disliked the answers and explanations given by the training. In fact, several participants reported that they learned from the explanations and the opportunity to receive feedback on their choices.

One participant did not like the way some elements of the training forced users to choose only correct answers. He thought a better system would be to allow them to make mistakes and then receive feedback. The following bulleted items summarize the recommendations of the participants.

- Allow review of previously studied content/pages
- Include a greater variety of examples
- Include more audio portions
- Clarify some of the explanations
- Simplify the vocabulary and language used in the explanations
- Consider eliminating the scoring
- Allow participants to choose the wrong answer

Comparison to alternate training group. Those participants who received the alternate training (based on training provided at CGSC) also evaluated their training. They took an average of 6 hours to complete their training, which some regarded as too short. They thought they needed more information to better understand the process of critical thinking. As a group, these participants called for more content. They did believe it was relevant to their study at the Army War College. One pointed out that the ability to perform logical reasoning in a standard format ensures comprehensive analysis. They thought it was good for overall officer development. As a group, they thought it was moderately interesting. One remark was "The training was okay. Training is training, you can't really get excited about it." They would recommend it and they think it would help their colleagues.

Performance Results

Scoring. Three measurable indicators of CT were used to score the responses provided by all participants on the assessment instrument. The three indicators constitute measures of memory, inference justification, and questions about the validity or veracity of information. Each indicator was derived from assumptions about CT in the general CT literature and/or in the model of CT described in Volume Two of this report. A memory indicator was included because CT, by definition, involves greater depth of processing. Hence, if CT is engaged, then processing of information will be deeper. The cognitive psychological literature commonly accepts the notion that memory for processed information improves as that processing deepens. Thus, memory for material may be used as an indicator of CT. The failure to justify inferences derived from the content of a message is an inverse indicator of CT. According to the CT model presented in Volume Two of this report, CT is driven by System Two processing. If one accepts the model's proposition that System Two processing involves checks on the products of the automatic activity of System One, then evidence that one has failed to engage in such checks would be an indicator that one has failed to critically think. Inferences derived from the content of a message are natural products of System One associational processes. However, failing to justify those inferences, even after instruction to do so, is evidence that System Two checks have not been applied to those System One products. Similarly, questioning the validity of given information in a message is direct evidence that System Two checks have been applied; hence, a positive indicator of CT.

The responses to the test questions that followed each message in the assessment instrument were scored for each of the three CT indicators. First, the amount of information remembered from each of the four messages in the test was scored. As previously indicated, each message was followed by a series of questions that asked participants to remember features of the message they had just read. The memory questions were scored for accuracy, and then the resulting memory scores were summed across the four messages to obtain a single memory score for each of the 19 participants.

To score the number of unjustified inferences made by each participant, all inferences (whether justified or not) made in the interpretation section of the assessment test were first identified and counted. A statement was judged to be an inference if it clearly contained content that was not provided by the relevant message. For example, several respondents indicated that the Al Qaeda author of the third message believed that the United States blames Afghani Muslims for the attack on the Twin Towers. This is a clear inference because no mention of the attack is made in the statement. Second, the number of inferences for which no justification was provided was counted. Justification was defined as any mention of information given in the message that a participant related to, and provided as evidence for, the inference they had made. Participants were awarded a single point for each unjustified inference they made. The points earned for each message were then summed across the four messages to obtain a single score that reflected the degree to which participants made unjustified inferences.

To determine the relative degree of questioning made by the three groups, the number of times participants expressed a question about the validity or veracity of information was counted for each message. Participants were awarded a single point each time they questioned or doubted information given to them in a message. The questions contained in the evaluation section of the assessment instrument were scored for this variable. The points earned for each message were then summed across the four messages to obtain a single score that reflected the degree to which participants questioned information that was given to them.

Experimenters who had not served as test administrators completed the scoring. Therefore, scorers had not met nor interviewed any of the participants and were blind to the experimental condition of the each participant.

Memory for information. The average number of items of information remembered from the four messages for the entire sample of individuals was 22.1 (SD = 6.4). The six participants who participated in the $(CT)^2$ training remembered significantly more pieces of information (M = 26.5, SD = 6.9) than did the individuals who took the alternative distance-based training ($t(9)$ = 1.971, p = .04, one tailed) (M = 19.8, SD = 4.1) and than the control group ($t(12)$ = 1.801, p = .04, one tailed) (M = 20.1, SD = 5.9). In other words, the $(CT)^2$ group recalled 31.6% more unique pieces of information than the control group and 33.8% more than the other distance-based training group.

Number of unjustified inferences. The average number of unjustified inferences produced by the entire sample of participants was 10.5 (SD = 7.8). The $(CT)^2$ training group produced significantly fewer unjustified inferences than the alternative distance-based training group ($t(9)$ = 5.056, p = .0005, one tailed) and the control group ($t(12)$ = 1.858, p = .04, one

tailed). The web-based training group made an average of 4.3 (SD = 1.6) inferences that they failed to justify with information given in the message. The alternative distance-based training produced nearly four times as many unjustified inferences (M = 18.0, SD = 6.4). The control group made 10.4 unjustified inferences on the average (SD = 7.8).

Questions of belief. The three groups did not differ with regard to the number of questions of belief produced.

Conclusions

The results of this research indicate that military students find $(CT)^2$ highly acceptable. Although the sample of participants who used $(CT)^2$ was small, it was uniformly positively rated. Despite the extensive time commitment the training program requires, users found it interesting and well worth their time. Participants thought the program offered training not available elsewhere in the Army. The self-paced feature of the program appears to be one of the reasons it received favorable reviews. Users thought it was highly relevant and beneficial to their military and civilian work.

Although $(CT)^2$ was well regarded, reviewers expressed several recommendations and it is clear that the usability of the program needs improvement. Specifically, the program needs to have greater ability to navigate to previous pages and more flexibility to use, or not to use, its audio components. Users also wanted more flexibility in their responses to allow them to actually make errors, which the program currently prohibits.

$(CT)^2$ also appears to be generally effective at encouraging critical thinking, at least about messages Army personnel must evaluate. The research clearly showed that the web-based training enhanced memory for messages, possibly because it encourages greater depth of processing in a number of ways. For example, the five modules studied by the participants were designed to sensitize students to errors they are likely to make when encoding a message. It teaches students to examine *the entire* message, attempting to dissuade them from overlooking any piece of information. It also teaches them to carefully examine weak components of a message and attempt to clarify their meaning. Finally, it helps students distinguish between given information in the message and their inferences or interpretations of the message. In doing so, $(CT)^2$ encourages a deeper processing of messages than people often engage in. The finding that memory of messages is enhanced after participating in $(CT)^2$ is a strong indicator that those messages have been processed at a deeper level.

$(CT)^2$ also seems to inhibit the production of inferences that go well beyond what is explicitly given in the message. Participants who took the $(CT)^2$ training made significantly fewer unjustified inferences than participants assigned to the other two training conditions. Examinations of the responses reveals that $(CT)^2$ participants did make inferences; however, they justified them by pointing out explicit information given in the message that supported their inferences. Therefore, $(CT)^2$ appears to encourage discrimination of what is "known" or "given" from what might be added (i.e., inferred) by the perceiver.

The ability to make this distinction is critical to avoiding many errors of reasoning. In these data, for example, participants who were inclined to make unjustified inferences expressed

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beliefs that were clearly erroneous. The fourth message of the assessment instrument is an excerpt of President Bush's introduction to the National Security Strategy that was written post September 11, 2001, but before the war in Iraq. When asked what President Bush meant by "poverty does not make poor people into terrorists and murderers," several participants provided the following answers, missing the President's point entirely. He means, "he does not intend to fight poor people," or "he does not intend to target poorer countries." The meaning of the President's statement is clear from other information given in the text: "Yet poverty, weak institutions, and corruption can make weak states vulnerable to terrorist networks…". If respondents had attended closer to what was *given* in the message, and knew that they were making an inference about his intentions to fight the poor, they would have realized that their inference was incorrect, i.e., that it was not the point President Bush was making. In other words, these results suggest that $(CT)^2$ encourages evidence-based reasoning.

The lack of significant differences among the groups on the questions of the belief variable is inconsistent with the other findings. One would expect those who better remembered specific information and stuck to the message closely when making inferences would also be more sensitive to vague or otherwise weak information given in a message. One would expect those same people to question whether they should believe information that they perceived as weak. However, the data did not uphold this prediction. It is possible that the evaluation questions did not adequately elicit judgments, which have been shown to encourage questioning in previous studies (See the validation investigation in Volume Two of this series). Alternatively, it may be that the training for the particular critical thinking skill that was the focus of this research (Frame the Message) is not particularly effective at eliciting questions about the validity of material. This investigation leaves this research question unresolved.

In summary, the present research provided an evaluation of $(CT)^2$ prototype, in terms of how well it is likely to be accepted by military users and its effectiveness at improving CT. Future research should focus on comparing the effectiveness of other CT training programs to $(CT)^2$ using alternative indicators of CT.

THE NEXT STEP:
EXPANDED WEB-BASED SYSTEM FOR TRAINING CRITICAL THINKING

This is the third volume of a three volume report which documents the foundational research for the development of a web-based training system for critical thinking. This research (1) reviewed the literature on critical thinking, (2) produced an innovative, testable, and partially validated model of CT, (3) identified eight critical thinking skills that are important and problematic to Army battle command, and (4) developed and evaluated a web-based training prototype that targets the development of two critical thinking skills for Army battle command, *Frame the Message and Recognize Gist in Material.*

This research underlies the expanded version of $(CT)^2$ (Fischer, et al., 2008) which offers training for all eight of the critical thinking skills. In addition to the two in the prototype $(CT)^2$, the following skills are also trained:

1. Develop an explanation that ties information elements together in a plausible way
2. Generalize from specific instances to broader classes
3. Visualize plans to see if they achieve goals
4. Recognize fallibility and bias in own opinion
5. Adopt multiple perspectives
6. Decide when to seek information based on its value and cost

Based on feedback from the prototype evaluations, extensive changes were made to the design of the training system. For example, more exercises within each module were developed to provide the opportunity for practice, performance feedback, and reinforcement. To help sustain user interest, each module is now a multimedia presentation with external inputs (voice, video, animation, text, and data). The ability of the user to maneuver around the system was improved.

In addition, a user's manual was developed (Fischer, Spiker, Harris, & McPeters, 2004). This ensures that $(CT)^2$ can be easily used by schoolhouse instructors and commanders who may wish to use it to train their units, The manual includes an overview of the training, and the learning objectives targeted by the system. It also guides the user in utilizing the training to obtain maximum change in the critical thinking of the targeted students. Expected outcomes, level of effort, and procedures are discussed.

Formative evaluations were a major component in the design and implementation of the expanded version of $(CT)^2$. Before proceeding with Web development, training content was reviewed by members of a panel composed of individuals who represented military experts and the target population of students. This panel of reviewers was recruited from the population of military retirees who develop curriculum for the Command and General Staff College. The reviewers assessed the content of each module for technical accuracy, relevance to tactical battle command, interest, educational value, and comprehensibility. The clarity of the cognitive and behavioral objectives was scrutinized, as were the answer keys to the practical exercises and

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tests. In keeping with the build-test-rebuild approach taken throughout the project, the reviews and revisions were conducted iteratively in two cycles.

Formative usability evaluations were also an integral part of the software design and implementation and four were conducted for the expanded version of $(CT)^2$. A user-centered design process was employed to construct the web-based $(CT)^2$ (Norman & Draper, 1986). The two foci of user-centered design are usefulness and usability. Because the identification of the eight critical thinking skills addresses usefulness, the user-centered design process for this software focused on usability. Achieving high usability with complex content is almost invariably the product of extensive testing, modification, and refinement. The purpose of this step was to determine whether our design and implementation leads to correct use. Are users taking full advantage of the designed capabilities? If not, why not? Do users correctly understand the content? What actions are available to them, and what will be the consequences of their actions?

The expanded training system has received positive evaluations from users (see Fischer, et al., 2008). The training has the advantage of being accessible by anyone with Internet access, which means that it could be used by any Army or reservist field unit anywhere in the world. It could also be used as distance learning or for residents at Army schoolhouses such as the Command and General Staff College, West Point, and the Army War College. In short, we believe it has wide applicability. In addition, the critical thinking skills it trains are universally important in situation assessment, decision making, and problem solving, whatever the population. $(CT)^2$ could be easily adapted to other user groups by tailoring the scenarios and examples.

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APPENDIX A: CRITICAL THINKING SKILLS IN THE LITERATURE

Interpretation Skills
1. Recognize central thesis in a work
2. Break goal into sub goals
3. Strip verbal argument of irrelevancies and rephrase it in essential terms
4. Extract meaning from context
5. Understand contextual nuances
6. Frame the message
7. Probe question or problem to obtain clarifying information
8. Question deeply
9. Redefine problem and goal
10. Seek clear statement of the question
11. Understand intended definition of certain words
12. Discern when a term is used with different meanings
13. Recognize need for operational definition
14. Identify and challenge assumptions
15. Identify unstated assumption in a discussion
16. Identify missing information from an argument
17. Identify premises and conclusions
18. Identify missing premises
19. Analyze ambiguities in arguments
20. Critique to distinguish reliable from unreliable assumptions
21. Distinguish fact/opinion/assumption elements in an argument
22. Distinguish relevant from irrelevant information
23. Examine evidence to distinguish anecdote from fact
24. Determine whether a statement is overly vague or overly specific
25. Identify own assumptions and biases
26. Identify emotional language in external sources
27. Distinguish between validity of a belief and intensity with which it is held
28. Seek disconfirming evidence
29. Know when causal claims can and can't be made

Reasoning Skills

1. Understand limits of extrapolation
2. Reason by finding analogous arguments to bolster conclusion
3. Refine generalizations and avoid oversimplification
4. Apply general principles to specific cases
5. Generalize from specific instances to broader classes
6. Determine whether a simple generalization is warranted
7. Draw inductive inference from observations
8. Reason by taking representative samples
9. Distinguish between deductive and inductive reasoning
10. Reason by deductive logic to draw conclusions from premises
11. Reason dialogically to identify and compare perspectives
12. Reason dialectically to evaluate points of view
13. Trace logic in an argument
14. Determine whether a statement follows from premises
15. Distinguish between logically valid and invalid inferences
16. Check consistency of information in the problem
17. Avoid *ad hominem* reasoning fallacy (consider argument not the person)
18. Avoid *false dichotomy* reasoning fallacy (artificially reduce the number of choices)
19. Avoid *guilt by association* reasoning fallacy
20. Avoid *emotional appeal* reasoning fallacy
21. Identify instances of faulty thinking
22. Mentally simulate plans to see if they achieve goals
23. Mentally generate a structure of possibilities that presently don't exist
24. Mentally simulate probable consequences of alternative
25. Develop and use mental models
26. Recognize bias in hindsight analysis
27. Reason from starting point with which one disagrees
28. Recognize fallibility of own opinion
29. Recognize probability of bias in own opinion
30. Recognize transitive relationships
31. Inference to "best explanation" that explains facts better than all other alternatives
32. Make reasoned value judgment by considering background, consequences, principles
33. Understand difference between reasoning and rationalizing
34. Analyze problem by working backward
35. Determine when evidence is insufficient to warrant sound conclusion

Assessment Skills
1. Know value and cost of information and how and when to seek it
2. Know when new information supports/refutes conclusion
3. Consider new evidence as it becomes available
4. Weigh multiple factors when necessary
5. Perform means-ends analysis to check status
6. Support general assertions with details
7. Frame decision in alternative ways
8. Assess an assertion's truthfulness based on accuracy of relevant facts
9. Assess an assertion's truthfulness based on its degree of precision
10. Assess an assertion's truthfulness based on presence of unbiased evidence
11. Assess an assertion's truthfulness based on having credible sources
12. Assess an assertion's truthfulness based on its logical consistency
13. Assess an observation's credibility based on short time between observation and report
14. Assess an observation's credibility based on first-hand report by observer
15. Assess an observation's credibility based on minimal interference
16. Assess an observation's credibility based on reporter's belief that observation was accurate
17. Assess an observation's credibility based on corroboration by other sources
18. Assess credibility of information source based on author's reputation for accuracy
19. Assess credibility of information source based on being in author's field of expertise
20. Assess credibility of information source based on absence of conflict of interest
21. Assess credibility of information source based on known risk to author's reputation
22. Assess credibility of information source based on data-gathering and processing methods
23. Assess credibility of information source based on agreement with other sources
24. Assess strength of conclusion based on reasonableness of assumptions
25. Assess strength of conclusion based on consistency with known facts
26. Assess strength of conclusion based on alternatives are inconsistent with known facts
27. Assess strength of conclusion based on its ability to explain the evidence
28. Assess strength of argument based on clarity of meaning
29. Assess strength of argument based on identity of stated and unstated conclusions
30. Assess strength of argument based on identity of premises supporting conclusions
31. Assess strength of argument based on identity of unstated assumptions
32. Assess strength of argument based on reliability and reasonableness of inferences
33. Assess strength of argument based on other relevant arguments
34. Assess quality of judgment based on kind of judgment being made
35. Assess quality of judgment based on presence of indicators related to the criteria
36. Assess quality of judgment based on pattern among indicators
37. Assess quality of judgment based on degree of match with criteria

Meta-Cognitive Monitoring Skills
1. Look beyond first obvious explanation to consider alternative interpretations
2. Identify the need to think hard
3. Develop perspective to explore the implications of beliefs, arguments, or theories
4. Ask questions and be willing to ponder (e.g., use scientific method)
5. Construct story that ties all information elements together in plausible way
6. Generate summaries
7. Generate alternative explanations
8. Generate multiple ideas
9. Adopt multiple perspectives
10. Consider multiple sides of an issue
11. Stay relevant to the main point
12. Take total situation into account
13. Monitor events for consistency with expectations
14. Monitor own understanding of problem
15. Compare analogous situations and transfer pertinent learning to new contexts
16. Know that observations are more credible than inferences based on them
17. Read between the lines
18. Determine whether argument depends on an ambiguity
19. Understand differences among conclusions, assumptions, and hypotheses

APPENDIX B:
TEACHING METHODS FOR PROMOTING CRITICAL THINKING

Teaching Method	Critical Thinking Skills	Reference	Type of Evidence
Guided Web Exploration: A basic set of navigation buttons to structure web exploration used in the context of hypothetical tasks on the Internet.	1. Determining the relevant from the irrelevant 2. Decide when to seek info. based on its value and cost 3. Decide when to consider new information or evidence 4. Seek disconfirming evidence	Baker (1997)	Testimonial
Conference style learning/Seminar	1. Make a reasoned value judgment by considering background, consequences, principles	Underwood & Wald (1995)	Testimonial
Evaluating Arguments— Students are required to analyze and evaluate competing arguments on an issue. Class discussions about the arguments are then engaged. Then, students write a paper in which they defend one of the arguments.	1. Assess the strength of a conclusion or argument	Bernstein (1995)	Testimonial
Evaluating arguments as problem solving methods. Students are trained to see competing arguments as defenses of solutions that come out of a particular representation of a problem.	2. Frame decision in alternative ways 3. Generate alternative explanations or interpretations	Bernstein (1995)	Testimonial
Negotiation Skill. Students learn about various sides of an issue such as animal research ethics. They see videos and read and evaluate arguments. They then form simulated animal research and care committees, taking on a role opposite to their personal position. They first have to draft a set of guidelines within the 4-person committee. They then have to decide on four protocols submitted to the committee. They are reminded to use "Getting to Yes" skill in identifying common interests. The model insists on treating all parties with respect and being genuinely empathic with their interests.	1. Assess the strength of a conclusion or argument 2. Adopt multiple perspectives 3. Reason from starting point with which one disagrees	Bernstein (1995)	Testimonial

Teaching Method	Critical Thinking Skill	Reference	Type of Evidence
Debate — the National Debating Team method, emphasizes a dialectical approach to arriving at truth. This approach emphasizes and judges arguments based on evidence brought forward to arrive at conclusions.	1. Base reasoning on observations because they are more credible than inferences based on them 2. Judge when evidence is insufficient to warrant conclusion	Colbert (1986)	Empirical. Positive Effect on WGCTA compared to Aristotelian approach
Debate — Aristotle's rhetoric approach to debate which acknowledges evidence but also emphasizes the use of persuasive techniques in argument.	1. Use persuasive techniques in argument	Colbert (1986)	Empirical. Positive Effect on WGCTA compared to control group
Teaching argument concepts like claim and evidence using modeling of argument evaluation, feedback of students argument evaluations about claim and evidence, and exercise in which claims and evidence are identified	1. Identify assumptions and challenge validity 2. Distinguish among conclusions, assumptions, hypotheses 3. Distinguish between facts and opinions 4. Distinguish relevant from irrelevant information 5. Judge when causal claims can be made 6. Judge when evidence is insufficient 7. Base reasoning on observations	Klein, Olson, & Stanovich (1997)	Empirical. Increased ability to evaluate arguments
Teaching strategies for planning and monitoring evaluation of an argument such as "I will be a careful idea shopper," "I'll try to figure out what the author wants me to believe."	1. Identify assumptions and challenge validity 2. Distinguish among conclusions, assumptions, hypotheses 3. Distinguish between facts and opinions 4. Distinguish relevant from irrelevant information 5. Judge when causal claims can be made 6. Judge when evidence is insufficient 7. Base reasoning on observations	Klein, Olson, & Stanovich (1997)	Empirical. Increased ability to evaluate arguments, and increased creation of evidence-based arguments
Within a course, encouraging doubt of written material, encouraging exploration of own opinions, encourage question and challenge of the instructor	1. Identify assumptions and challenge their validity 2. Identify own assumptions and biases 3. Adopt multiple perspectives 4. Identify common fallacies	Huff (2000)	Empirical. Improved CCTST scores

Teaching Method	Critical Thinking Skill	Reference	Type of Evidence
Collaborative learning-- students were instructed to discuss why they thought as they did regarding solutions to the worksheet problems. They were also instructed to listen carefully to each member of the group and to reconsider their own judgments. Every group member was required to contribute his or her ideas.	1. Recognize fallibility and likely bias of own opinion 2. Assess quality of own judgment based on indicators related to criteria	Gokhale (1995)	Empirical. Produced better scores on CT items than individual training
Students are asked to explain why, identify causes, determine the nature of, identify why something is important, identify the implications of, determine how something is affected, what is the solution?	1. Seek clear statement of question 2. Construct story that ties all information 3. Judge when causal claims can be made 4. Use deductive logic 5. Draw inductive inferences	Hittner (1999)	Empirical. Self report of students taking the course indicated improvement in CT.
Structure curriculum around ideas, not facts or themes. Model CT. Use demonstrations as opportunities for mutual thought. Discussion groups	No CT skills were trained, but the predisposing attitudes of curiosity, skepticism, reflective style, confidence, and willingness to engage in neutral effort were.	Gray (1993)	Testimonial
Introduce controversy in class, ask provocative questions, ask questions that inform what the student is learning, use essays not multiple choice, do this in all classes	No CT skills were trained, but factors that "encourage CT" include: introducing controversy, asking provocative questions, using testing instruments which promote active learning (essay), and integrating efforts across the curriculum.	Browne, Hoag, & Berilla (1995)	Testimonial

Teaching Method	Critical Thinking Skill	Reference	Type of Evidence
Provide explicit instruction in forming generalizations. Students given lecture and text, guided practice in groups, criteria checklists for generalizing, discussion groups.	1. Refine sweeping generalizations 2. Generalize from specific instances to broader classes 3. Determine whether a simple generalization is warranted 4. Distinguish between facts and opinions 5. Distinguish among conclusions, assumptions, and hypotheses 6. Distinguish between validity of belief and intensity with which it is held 7. Draw inductive inference from observations 8. Distinguish between logically valid and invalid inferences 9. Base reasoning on observations 10. Detect inconsistencies 11. Judge when evidence is insufficient 12. Judge when causal claims and can't be made	Kemp & Sadoski (1991)	Empirical. Improved generalization, but overall CT did not improve as measured by the CCTT.
Infusion approach. Instruction included special thinking activities that involved problem solving, analysis of experiments, and data handling. Different contexts were used	1. Determine whether a simple generalization is warranted 2. Judge when evidence is insufficient 3. Distinguish between logically valid and invalid inferences 4. Reason by taking representative samples 5. Base reasoning on observations 6. Distinguish between inductive and deductive reasoning 7. Use deductive logic to draw conclusions 8. Distinguish among conclusions assumptions and hypotheses 9. Distinguish between facts and opinions 10. Identify assumptions and challenge their validity 11. Identify and assess validity of unstated assumptions 12. Detect missing operational definitions 13. Identify missing information 14. Distinguish relevant from irrelevant	Zohar, Weinberger, & Tamir (1994)	Empirical. Improvement on general and domain specific tests of CT. Transfer was also achieved.

Teaching Method	Critical Thinking Skill	Reference	Type of Evidence
Generate thought provoking questions. Stems of questions include: compare and contrast, create analogies, judge importance, provide evidence, generate multiple perspectives, predict outcomes, etc.	1. Redefine problem 2. Break overall goal into subgoals 3. Seek clear statement 4. Reason dialogically 5. Reason dialectically 6. Distinguish between inductive and deductive 7. Distinguish between valid and invalid 8. Use analogous arguments 9. Explore implications of beliefs 10. Generate alternative explanations 11. Identify assumptions and challenge 12. Identify own assumptions 13. Judge when causal claims can be made 14. Draw inductive inferences 15. Adopt multiple perspectives 16. Support general assertions with facts 17. Assess strength of conclusion	King (1995)	Testimonial
Assign roles in a group that involve different thinking tasks. These include task definer, strategist, monitor, challenger	1. Seek a clear statement of the problem 2. Distinguish relevant from irrelevant 3. Identify assumptions and challenge 4. Identify missing information 5. Detect inconsistencies 6. Use deductive logic 7. Reason dialogically 8. Draw inductive inference 9. Monitor own understanding 10. Support general assertions with facts	Riesenmy, Mitchell, Hudgins, & Ebel (1991)	Empirical
Methodological education in a probabilistic science — graduate education	No CT skills were trained. The training examined was that provided in four graduate programs: law, medicine, psychology, and chemistry.	Lehman, Lempert, & Nisbett (1988)	Empirical. Education improves reasoning ability
Group discussion vs. traditional lecture method	No CT skills were trained. Treatment consisted of group discussion and group writing.	Garside (1996)	Empirical. No improvement in CT ability
Critical Analysis—Have students critique material, focusing on questions that require deep thinking, e.g., compare and contrast, why, what is most pressing need, etc.	Not stated. Presumably: 1. Mentally generate structure of possibilities. 2. Mentally simulate probable consequences of an alternative.	Jones & Safrit (1994)	Testimonial

Teaching Method	Critical Thinking Skill	Reference	Type of Evidence
Debate Teams—Have students debate topic, particularly effective if learners are asked to serve on a debate team whose position differs from that of their own.	Not stated. Presumably: 1. dialogical reasoning	Jones & Safrit (1994)	Testimonial
Dramatization—Students view a portion of a video and then script and act out a potential ending	Not stated, unclear.	Jones & Safrit (1994)	Testimonial
Action Maze—Students are divided into small groups and presented with situations. They must identify their responses to the situation as well as the consequences of each alternative.	1. Mentally generate structure of possibilities. 2. Mentally simulate probable consequences of an alternative.	Jones & Safrit (1994)	Testimonial
Critical Incident—A portion of a situation is presented to learners who then must make a decision about solving the problem. The teacher then points out additional information that the learner may have overlooked.	Not stated. Presumably: 1. Identify missing information. 2. Support general assertions with specific facts. 3. Seek disconfirming evidence.	Jones & Safrit (1994)	Testimonial
Scenario Building—Develop a detailed written description of a specified situation	Not stated, unclear.	Jones & Safrit (1994)	Testimonial
Socratic Questioning—Presenting questions that evoke ideas and viewpoints, explore applications, and provide implications.	No CT skills trained.	Jones & Safrit (1994)	Testimonial
Creative Visualization—Creating mental images of hypothetical situations	1. Mentally generate a structure of possibilities.	Jones & Safrit (1994)	Testimonial
Journal Writing—reflect on actions and behaviors related to program topic	No CT skills trained.	Jones & Safrit (1994)	Testimonial
Quotations or cartoons—presentation of thought provoking quotations or cartoons with discussion following.	No CT skills trained.	Jones & Safrit (1994)	Testimonial
Inventing—Student invents or designs new products, services, or teaching strategies.	1. Mentally generate structure of possibilities. 2. Mentally simulate plans to see if they achieve goals. 3. Support general assertions with specific facts.	Jones & Safrit (1994)	Testimonial
Pluses, minuses, and alternatives—List the pluses, minuses, and implications (PMI) of each alternative decision.	No CT skills trained.	Jones & Safrit (1994)	Testimonial
Train abstract logic principles coupled with examples of selection problems	Wason card test—deductive logic	Cheng, Holyoak, Nisbett, & Oliver (1986)	Empirical. Improves deductive reasoning

Teaching Method	Critical Thinking Skill	Reference	Type of Evidence
Competitive forensics in communication classes	argument creation and evaluation	Allen, Berkowitz, Hunt, & Louden (1999)	Empirical. Improves CT on Watson Glaser more than argumentation and public speaking
Argumentation training in communication classes	argument creation and evaluation	Allen, Berkowitz, Hunt, & Louden (1999)	Empirical. improves CT on Watson Glaser more than public speaking
Public speaking in communication classes	argument creation and evaluation	Allen, Berkowitz, Hunt, & Louden (1999)	Empirical. improves CT
Training pragmatic reasoning schemas like a permission schema and an obligation schema	deductive reasoning with the conditional, standard logic skills	Cheng, Holyoak, Nisbett, & Oliver (1986)	Empirical. but training in abstract principles is useful only if it is paired with training on pragmatic reasoning schemas

APPENDIX C:
IDENTIFICATION OF EIGHT HIGH-PAYOFF CRITICAL THINKING SKILLS FOR BATTLE COMMAND
(Taken from Fischer, Spiker and Riedel (2008b) and duplicated here for convenience.)

A two-tiered approach was used to select a set of high-payoff critical thinking skills used in battle command. At the first tier, the field was narrowed by identifying six broad classes of tasks from the original 13 that were evaluated by the participants in the Fort Hood interviews. The first cut was made by jointly considering two criteria based on the Fort Hood survey data. First, the mean importance ratings of the 13 broad classes of skills were taken into account. Second, we considered the number of officers who reported that they had observed problems in executing the 13 broad classes of tasks.

The mean importance ratings are presented in the far right-hand column of Table 4 (of Volume Two) and their significance was previously discussed. The number of officers who reported they had observed problems with each task class is also given in that table. Figure C-1 plots each task class in terms of its rated importance (x-axis) and number of reported problems (y-axis). To systematize the selection process and equally weight the two criteria, cross-hairs are placed on the figure to demark lines along the x- and y-axes where reasonable cutpoints could be placed. Using this approach, the broad classes of skills located in the upper left quadrant were selected. As shown in Figure C-1, there are six such classes that satisfy the criteria of having a sufficiently low (where 1 = high importance, 5 = low importance) importance rating (below 1.7 indicating officers thought they were very important) and a large incidence of problems (more than 7 officers out of 18 reported they had observed problems). Using these criteria, the six classes of critical thinking skills that deserve the most vigorous investigation in future research are:

- Framing the problem
- Inductive reasoning
- Mental simulation
- Avoiding reasoning fallacies
- Meta-reasoning
- Extracting meaning.

Figure C-1. Ratings of importance (x) by reported problems (y) for 13 broad classes of critical thinking skills.

However, over 40 tasks may be associated with these six broad classes. Thus, a second cut was applied to narrow the field to a set of particular skills on which to focus further research. We relied heavily upon the officer's incident reports and comments about each class of skill to make the final selection of eight critical thinking skills that would ultimately be the focus of future research. In addition to participant's comments, The following four criteria were applied. The greatest weight was given to the second selection criteria. Hence, each of the eight tasks was

primarily chosen because it was used in a particular battle command task for which deficiencies had been observed by the interviewees.

- all six classes identified should be represented in the final selection
- the task should be used in the performance of particular battle command tasks identified as problematic in the Fort Hood survey
- the underlying cognitive processes of the task should be potentially measurable
- the task should be applicable to future research and training development efforts.

Application of these criteria resulted in the identification of eight high-payoff critical thinking skills, listed in the middle column of Table C-1. The six broad classes can be seen in the left-hand column, with associated battle command tasks noted in the right-hand column. These tasks come from a taxonomy of 36 battle command tasks that were consistently found to have serious human performance problems during post and field exercises (Fallesen, 1993). The task list was organized around the taxonomic categories of mission, terrain, enemy, own forces, courses of action (COAs), battlefield, and planning (Fischer, Spiker, & Riedel, 2007b).

Table C-1. Core Critical Thinking Skills Selected for Future Research

Critical Thinking Class	Selected Critical Thinking Skill	Associated Battle Command Tasks
Frame the Problem/Extract Meaning from Material	Frame the Message	• **Clarify intent of commanders 1 and 2 levels up** • Review a mission statement • Determine own unit's area of responsibility from OPORD • Determine constraints/restraints placed on mission by higher HQ from OPORD
Extract Meaning from Material	Recognize Gist In Material	• **Review a mission statement** • Clarify commanders' intent 1 and 2 levels up
Induction	Develop An Explanation That Ties Information Elements Together In A Plausible Way	• **Interpret reports of recent enemy significant activities in area of interest** • Clarify intent of commanders one and two levels up • Read the battlefield • Track the battlefield • Interpret reports of enemy disposition
Induction	Generalize From Specific Instances To Broader Classes	• **Interpret reports of enemy disposition** • Interpret reports of recent enemy significant activities in area of interest
Frame the Problem/ Simulation	Visualize to Evaluate Plans	• **War game a COA** • Develop branches/sequences for each COA • Determine ease of movement • Perform terrain analysis to gain an appropriate perspective that supports battle • Predict number of vehicles that can fit in an engagement area

Avoid Reasoning Fallacies	Challenge One's Bias	• **Change own-unit plans based on new tactical input** • Develop COA's • Read the battlefield • Track the battlefield • Assess the situation • Infer status of enemy forces
Meta-Reasoning	Examine Other Peoples' Perspectives	• **Interpret reports of recent enemy significant activities in area of interest** • Infer status of enemy forces • Interpret reports of enemy disposition • Read the battlefield • Track the battlefield • Assess the situation
Meta-Reasoning	Decide When To Seek Information Based On Its Value And Cost	• **Assess the situation** • Interpret reports of enemy disposition • Interpret reports of recent enemy significant activities in area of interest • Read the battlefield • Track the battlefield • Infer status of enemy forces

The interview data obtained at Fort Hood confirmed that these battle command tasks are problematic, i.e., officers reported that they had observed deficiencies related to CT in these battle-command tasks. Interview respondents identified the battle command tasks for which deficiencies in CT were most evident and troublesome. As noted above, these reports were central to identification and selection of the eight critical thinking skills. Greater weight was given to battle command tasks that were noted by several officers. For example, quite a few of the interviewees reported that commander's intent statements were difficult to write and to understand. The purpose of commander's intent statements is to provide the central objective and intention of the mission. However, that goal is rarely achieved, according to our respondents. Another commonly noted problematic battle command task was the inability to recognize one's own biases, which manifested itself in "fighting the plan." Many interviewees conveyed experiences in which new and contrary evidence (e.g., changes in expected enemy avenue of approach) was ignored or interpreted to fit the plan. Thus, decisions were made to continue with the original battle plan, often with disastrous results. Table C-2 further defines and clarifies the problems associated with each of the eight selected critical thinking skills. A definition of each task is given in the third column. The primary battle command task for which deficiencies were noted in the interview, and for which the CT task was chosen, is given in the fourth column. The fifth column describes the kind of errors and deficiencies that were reported by the Fort Hood officers.

Table C-2. Relationship of Battle Command Tasks, CT Issues and Selected Critical Thinking Skills

Critical Thinking Skill (CTS)	Critical Thinking Skill Title	Critical Thinking Skill Definition	Primary Battle Command Task	Battle Command Issue
1	Frame The Message	The ability to identify the essential elements of a message, understand their relationships, and describe a high fidelity representation of the message.	Clarify the intent of the commanders 1 and 2 levels up	1. Difficulty in establishing clear and accurate understanding of CDR intent. 2. Difficulty in conveying clear CDR intent.
2	Recognize Gist In Material	The ability to sort through the details in a message (written, graphical, visual, auditory, and/or tabular) and extract the gist therein.	Restate mission objectives provided by upper echelon to write own mission statement	1. Too much detail in OPORDS that must be filtered to establish gist that supports writing of own mission statement 2. Too little time at lower echelons to accurately extract essence of mission
3	Develop An Explanation That Ties Information Elements Together In A Plausible Way	The ability to: • Arrange evidence logically • Highlight the gaps in knowledge. • Develop an explanation or multiple explanations based on evidence Evaluate explanation(s) for plausibility	The ability to: • Arrange evidence logically • Highlight the gaps in knowledge. • Develop explanations based on evidence • Evaluate explanation(s) for plausibility	The ability to: • Arrange evidence logically • Highlight the gaps in knowledge. • Develop an explanation or multiple explanations based on evidence Evaluate explanation(s) for plausibility
4	Generalize From Specific Instances to Broader Classes	The ability to recognize and then classify specific facts/incidents/events as part of a general category.	Interpret reports of enemy disposition	1. Fail to accurately induce patterns of overall movement based on report instances 2. Tendency to disregard reports that do not match expectations 3. Tendency to inflate information in reports
5	Visualize To Evaluate Plans	The ability to accurately create mental images in one's mind how resources will be applied and events will unfold within a situation.	Develop scheme of maneuver War game COAs	1. Fail to visualize events 2. Fail to include sufficient detail in COAs 3. Fail to consider contingencies 4. Fail to consider how plans could go wrong 5. Generate only one COA 6. Fail to consider combat multipliers 7. Difficulty in keeping track of mobile forces

6	Challenge One's Bias	Ability to reevaluate one's current view of the situation for prejudice or bias as new information is received.	Change own-unit plans based on new tactical input	1. Tendency to "fight the plan" 2. General reluctance to change plans
7	Examine Other Peoples' Perspectives	The ability to view and interpret a set of circumstances from the perspectives of different individuals, different cultures/religions, and different timeframes (historical perspective).	Interpret reports of recent enemy activities in area of interest	Fail to accurately estimate enemy intent
8	Decide When To Seek Information Based On Value And Cost	The ability to evaluate the need for of new information in terms of its cost in Time, resources, and risk.	Assess current situation	Tendency to ; -spend too much time planning and gathering information -make quick decisions without gathering more information