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What Do Trainers Need to Know to Train Higher-Order Thinking Skills?

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14. ABSTRACT

This is the first in a series of two research reports concerning Army instructor preparation for training higher-order thinking skills, such as decision-making and problem-solving. In this report, a training needs analysis (TNA) was conducted to determine what Army instructors/trainers need to know in order to train higher-order thinking skills. While the focus of the TNA was on Air Defense Artillery Patriot Unit trainers, many of the recommendations derived may be more broadly applicable to instructors/trainers working in other Army training domains. The report presents the results of the TNA, as well as a review of higher-order thinking skills, and recommended strategies, methods, and techniques to enhance training for higher-order thinking skills to support Soldiers in making decisions under uncertainty.

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WHAT DO TRAINERS NEED TO KNOW TO TRAIN HIGHER-ORDER THINKING SKILLS?

EXECUTIVE SUMMARY

Research Requirement:

This research sought to characterize the complementary training needed by Army instructors to support their ability to train Soldiers in making decisions under uncertainty, an activity requiring Soldiers to apply complex, higher-order thinking skills. Here, the researchers sought to define what instructors/trainers need to know in order to train Soldiers in higher-order thinking skills using a training needs analysis methodology. Although the focus of the training needs analysis was on decision-making and problem-solving training for Air Defense Artillery instructors/trainers, the findings of the research are broadly applicable across the Army.

Procedure:

Military and scientific literature was reviewed to identify instructor training relevant to developing higher-order thinking skills for decision-making and problem-solving. Observations and interview data were collected with Air Defense Artillery (ADA) subject matter experts at Forts Sill (OK), Hood (TX), and Bliss (TX) in support of a training needs analysis. A training needs analysis method was used to identify specific topic domains to include in complementary training for instructors to assist them in developing learners' higher-order thinking skills. The particular focus of the recommendations is on instructors at the unit level, as these trainers are most responsible for training the complex tactical engagements skills that require Soldiers to apply higher-order thinking to decision-making and problem-solving scenarios.

Findings:

Due to the fact that Air Defense training is highly technical, it often relies on training techniques that emphasize remembering, understanding, and applying technical systems knowledge and procedures. That said, in practice, ADA Soldiers are required to make sense of a vast array of, at times, incomplete data to visualize the battlespace and make complex engagement decisions, while weighing various contextual factors and adhering to the rules of engagement. This requires ADA Soldiers to engage in higher-order thinking to support their decision-making and problem-solving processes. In this report, we identify critical situations in ADA that elicit complex decision-making and problem-solving as well as make more general recommendations for what Army instructors need to know in order to train these skills. Our recommendations are drawn from the scientific literature on training higher-order thinking skills and applying adult learning techniques, supporting the Army's current learning model.

Utilization and Dissemination of Findings:

As the first in a series of two reports, this report covers the background research supporting the development of an 8-hour training program for ADA instructors/trainers focused on how to train higher-order thinking skills. The second report will present the research product: the 8-hr block

of training. This training was provided to instructors at the ADA schoolhouse and to unit trainers at the 108th ADA BDE at Fort Bragg, NC. The results of the research were briefed to the U.S. Army Air Defense Artillery School (USAADASCH) leadership at Fort Sill, OK, in Oct 2016. Aspects of this research were also presented at the Department of Defense Lab Day Event at the Pentagon, Washington, DC, in May 2017.

WHAT DO TRAINERS NEED TO KNOW TO TRAIN HIGHER-ORDER THINKING SKILLS?

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Introduction

The Army's learning model and human dimension initiatives seek to develop and refine Soldiers' thinking skills in support of problem-solving, decision-making, perceptual processing, and information processing (U.S. Department of the Army, TRADOC, 2011; 2014). Current Army training presents many opportunities to train complex cognitive skills. However, most Army instructors have not been prepared to train these skills (National Research Council, 2015). This research sought to identify what instructors need to know in order to develop trainees' higher-order thinking skills. In brief, instructors should be able to recognize when opportunities arise to train these skills as well as be proficient in techniques to do so. By harnessing their own and others' military experience, instructors should be able to vary training activities and problem scenarios realistically. Trainees will be less likely to become complacent in training when instructors expose them to varying and unexpected training activities and exercises (Bransford & Schwartz, 1999).

Air Defense Artillery instructors/trainers were the initial target audience for the products of this research. Even so, many of the recommendations we derived from a training needs analysis are broadly applicable to instructors/trainers who conduct training in other areas of the Army.

Background on the Research Problem

The Army is limited in terms of training time and resources available. Training to enhance complex, higher-order thinking skills takes time. Given limited time, one could argue that the Army should focus on training through repetitive practice. Repetitive practice enables Soldiers to learn to execute critical tasks quickly, consistently, and proficiently. Repetitive practice makes skilled performance consistent for Soldiers and predictable for Leaders. Leaders need to know that Soldiers can execute tasks proficiently, even in highly stressful combat conditions.

A problem arises, however, when Soldiers encounter novel situations. Through repetitive practice, a Soldier gets good at executing a specific skill in a specific context. Real-world situations often do not exactly replicate those encountered in training. Soldiers must be able to transfer what they have learned into unforeseen situations. This requires thinking skills that are more complex than those developed through repetitive practice alone. While training in a way that develops higher-order thinking skills may take more time, it may have the advantage of helping Soldiers to develop decision-making and problem-solving abilities that are widely applicable.

Creating the conditions to train higher-order thinking skills is directly associated with applications of particular training techniques. Most instructors/trainers default to using the training techniques their own trainers used. They know they can apply these familiar techniques competently. Instructors need to be aware of how higher-order thinking skills can be elicited in training in order to target them effectively (Miri, David, & Uri, 2007). By varying what Soldiers

experience in training, instructors may enhance Soldiers' ability to generalize principles from what they are learning (Bransford & Schwartz, 1999). Instructors must also understand how to communicate in ways that elicit complex cognition in the classroom. Instructors need to be able to recognize and utilize the opportunities they encounter to create variation in training, thereby disrupting Soldiers' expectations and engaging them in complex forms of thinking (Pohl, 2000).

What Are Higher-Order Thinking Skills?

A traditional way to classify thinking skills is hierarchically. Within a hierarchical scheme, higher-order thinking skills depend on those of a lower-order (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). Lower-order thinking skills include those related to knowing, comprehending, and applying information. Higher-order thinking skills include analyzing, synthesizing, and evaluating information. In other words, *understanding a concept* is associated with a lower-order of thinking skills than is *combining a concept with other concepts to solve a real-world problem*. As Bloom et al. (1956) observe, one cannot apply a concept until one knows and comprehends it; likewise, one cannot analyze a concept until one knows, comprehends, and applies it.

The taxonomy of cognition proposed in Bloom et al. (1956) has continued to evolve in contemporary psychological research (see Anderson & Krathwohl, 2001; Wilson, 2013). The major change from Bloom's original taxonomy is that researchers now refer to thinking skills as verbs rather than nouns: *knowledge* became *remembering*; *comprehension* became *understanding*; *application* became *applying*; *analysis* became *analyzing*; *synthesis* became *creating*; *evaluation* became *evaluating* (Anderson & Krathwohl, 2001).

This may at first seem to be an irrelevant distinction. Using verbs rather than nouns emphasizes that thinking is not an abstract, conceptual thing that exists apart from us. It is instead what we do constantly every day. As an example of this point, consider the meaning of *knowledge* in relation to the meaning of *remembering*. *Knowledge* is an abstract thing that, theoretically, has an amount that can be measured. *Knowledge* is an abstract concept. To *know* something, however, is different. That we *know* something can be reflected in our ability to *remember* it. *Remembering* is a familiar, everyday thing we do. As an action, *remembering* can be practiced; through practice, one can get better at it. It is by observing a person remembering that we make inferences about specific things they know, and over time, their base of knowledge. By naming thinking skills with verbs, we are able to identify more clearly how we might go about improving individuals' specific thinking skills. It is a subtle distinction, but an important one for contemporary psychology.

Some psychologists, such as de Bono (1985), have developed specific techniques to enhance thinking skills. Many of these techniques have been made popular by the self-improvement and secondary education literature. For instance, there is a movement in American secondary education to develop higher-order thinking skills (Teach for America, 2011). A number of classroom activities have been devised specifically to develop higher-order thinking skills. Increasingly more complex skills such as judgment, critical thinking, and problem solving are purportedly improved by having students engage in activities such as:

- visualizing a problem by diagramming it,
- separating relevant from irrelevant information,
- seeking reasons and causes,
- justifying solutions to problems,
- seeing more than one side of a problem,
- weighing sources of information based on their credibility,
- revealing assumptions in reasoning, or
- identifying bias or logical inconsistencies.

In the research literature, cognitive processes have been classified into increasingly complex terminologies. For instance, Anderson and Krathwohl (2001) have distinguished six levels and 19 categories of cognitive processes. Table 1 provides a synopsis of terms as well as associated thinking skills.

Table 1
Contemporary Terminology Describing Thinking Skills

Thinking Skill	Descriptive Terms	Additional Examples
Create	**Generate –** hypothesize **Plan** – design **Produce** – construct	invent, compose, predict, imagine, propose, devise, formulate, combine, originate, forecast, invent, assemble
Evaluate	**Check** – coordinate, detect, test **Critique** – judge	select, choose, decide, justify, debate, verify, argue, recommend, assess, discuss, rate, prioritize, determine, criticize, weigh, value, estimate, defend, convince, support, score
Analyze	**Differentiate** – discriminate, distinguish, focus, select **Organize** – find coherence, integrate, outline, parse, structure **Attribute** – deconstruct	examine, investigate, separate, take apart, differentiate, subdivide, deduce, compare, contrast, infer, calculate, monitor
Apply	**Execute** – carry out **Implement** – use	solve, construct, compute, complete, make, put together, change, produce, calculate, manipulate, modify, demonstrate
Understand	**Interpret** – clarify, paraphrase, represent, translate **Exemplify**– illustrate, instantiate **Classify** – categorize, subsume **Summarize** – abstract, generalize **Infer** – conclude, extrapolate, interpolate, predict **Compare** – contrast, map, match **Explain** – construct models	outline, discuss, distinguish, predict, restate, describe, relate, summarize, convert, visualize, describe, sketch
Remember	**Recognize** – identify **Recall** – retrieve	tell, list, locate, write, find, state, name, label, define, reproduce, memorize, select, recite

Training Higher-Order Thinking Skills

Higher-order thinking skills enable us to develop new knowledge. That is, higher-order thinking skills enable learners to recognize and solve novel problems, as well as adapt what they have learned to changing circumstances. When faced with unfamiliar situations, learners need to be able to apply skills related to analyzing, synthesizing, and evaluating information to go beyond what they currently know. It is by way of these skills that learners may engage with more complex knowledge domains and learning situations (Paul & Nosich, 1992).

Enhancing higher-order thinking skills is a common educational goal (Teach for America, 2011). However, secondary education has historically relied on techniques that elicit and develop lower-order thinking skills: remembering, understanding, and applying. A lot of Army training can be categorized similarly. There is a functional purpose to this emphasis. Teaching that is oriented to recalling and applying facts allows for standardized teaching and evaluation processes (Barnes, 2007). On a standard recall test, a student can get an answer right (i.e., recalling it correctly) or wrong (i.e., not recalling it correctly). Performance outcomes are less contestable and distinctions among levels of performance are clear-cut. Students are rewarded for remembering, understanding, and correctly applying facts. For younger learners, this approach may be appropriate; for adults, it can be limiting (Nihill & Stallings, 2014).

Thinking is always *about* something (James, 1890[1983]). Teaching higher-order thinking skills requires a vehicle, that is, content about which the learner can think. The content needs to be presented in a way that encourages thinking. To develop thinking skills, professional training often makes use of ill-structured problems or case studies. These types of training materials present students with situations that "require the ability to recall useful information quickly, use pattern recognition, discern pertinent information, think ahead, and anticipate outcomes and problems while remaining composed so that emotions do not hinder decision making skills" (American Dental Education Association, 2015). Training higher-order thinking skills requires content and context about which students can think.

Finally, many techniques for training higher-order thinking skills elicit a shift in perspective. For instructors/trainers and learners, the shift calls attention to one's own and others' thinking processes, a phenomenon called metacognition (Flavell, 1979). Developing skills in metacognition may enable learners to self-regulate, streamline, and ultimately improve their thinking. Exposing learners to ill-structured problems may elicit higher-order thinking; working with others through contrasting, sometimes conflicting, examples and interpretations may extend this process further (Schwartz, Chase, Oppezzo, & Chin, 2011).

Higher-Order Thinking Skills: Decision Making Under Uncertainty

Organizations seek to improve thinking skills because they are foundational to the decision-making process. A decision removes options and locks us into a set of actions and consequences. We often do not know everything we need to make a perfect decision; we decide under conditions of uncertainty. Well-executed decision-making mitigates the inherent risk of uncertainty.

There are two basic perspectives on decision-making: normative and descriptive (Kahneman, 2011). A normative approach to decision-making focuses on how people ought to make decisions. It assumes that human beings are ultimately rational, motivated in our decisions to get more of what we like and less of what we do not like. When we deviate from a rational basis, it is because the world is imperfect—we lack information, viable options, etc. Otherwise, we would always act in predictable ways to obtain what we value. Descriptive decision-making is based on what researchers actually observe about the behaviors of decision-makers in everyday life. What we actually do when making a decision is more important to descriptive researchers than what we should do according to an abstract economic model (Klein, 2008).

When making everyday life decisions, it would seem that we decide based on what we perceive in a situation, and how we relate what we perceive to our experiences (Klein, 2008). We often make quick, error-prone, even risky decisions. To counteract this risk, we may offload aspects of the evaluative process using techniques—like the Military Decision Making Process—that tend to frame a decision in a systematic, almost mathematical, way. Being thorough and precise takes time. For some decisions, however, there is not enough time. Decision-making needs to be quick and intuitive in some critical situations, methodical and precise in others. Ideally, a decision-maker will develop skill in both approaches to decision-making and know when to apply the respective techniques appropriately, engaging in self-regulation around the decision-making process. Figure 1 presents a general decision-making process.

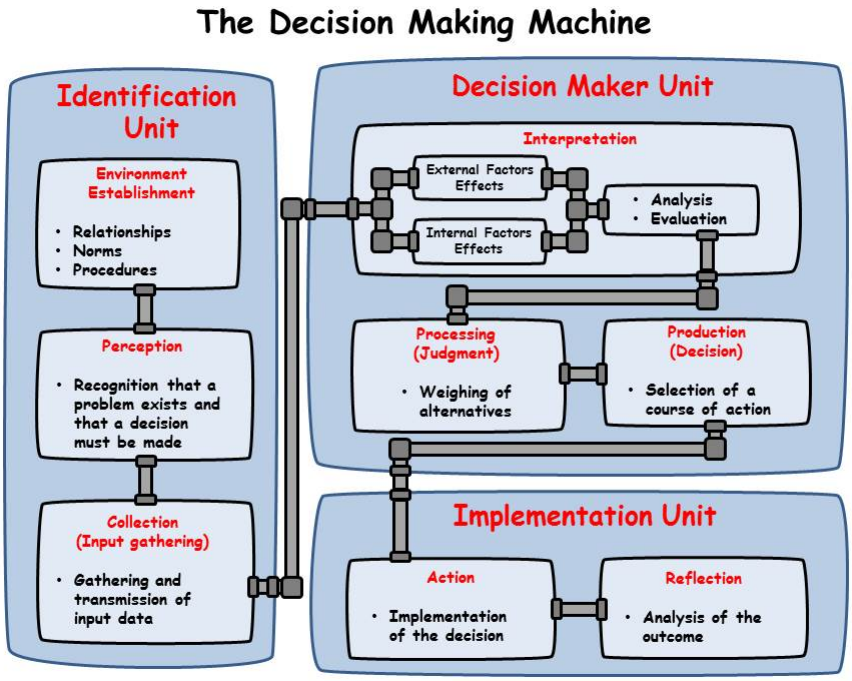

Figure 1. The Decision Making Machine

Decisions are guided by internal and external factors about which decision-makers may have inconsistent information (Luft, 1970). When we realize our information is incomplete or of uneven quality, time is limited, the situation changes during the decision process, and/or there is too much irrelevant information (i.e., noise), decision-making can become stressful (Zhang, Ji, & Looney, 2002). One way to help decision-makers become less reactive to this stress is to expose them in training to progressively more uncertain conditions with increasingly higher stakes, followed by an after-action review (AAR). This technique provides a stress-free context in which to reflect on one's decision-making process while being stressed.

Internal and external factors that influence decision-making are apparent in varying degrees. External factors that are immediately present in our environment and that are directly influencing our task tend to be those that can readily be perceived. Internal factors are less apparent. Nonetheless, internal factors may influence the decision-making processes. Internal

factors include existing experiences and skills, personality traits, and preferred ways of approaching problems (i.e., *heuristics*) and preferred ways of interpreting things (i.e., *biases*). It is often very difficult to manipulate internal factors directly. So, effective trainers must manipulate external factors in the world (e.g., characteristics of the problem-set or context) in order to elicit and develop the internal factors guiding the decision-maker. Figure 2 depicts the process how decision-makers collect information and the influences of internal and external factors on the decision-making process.

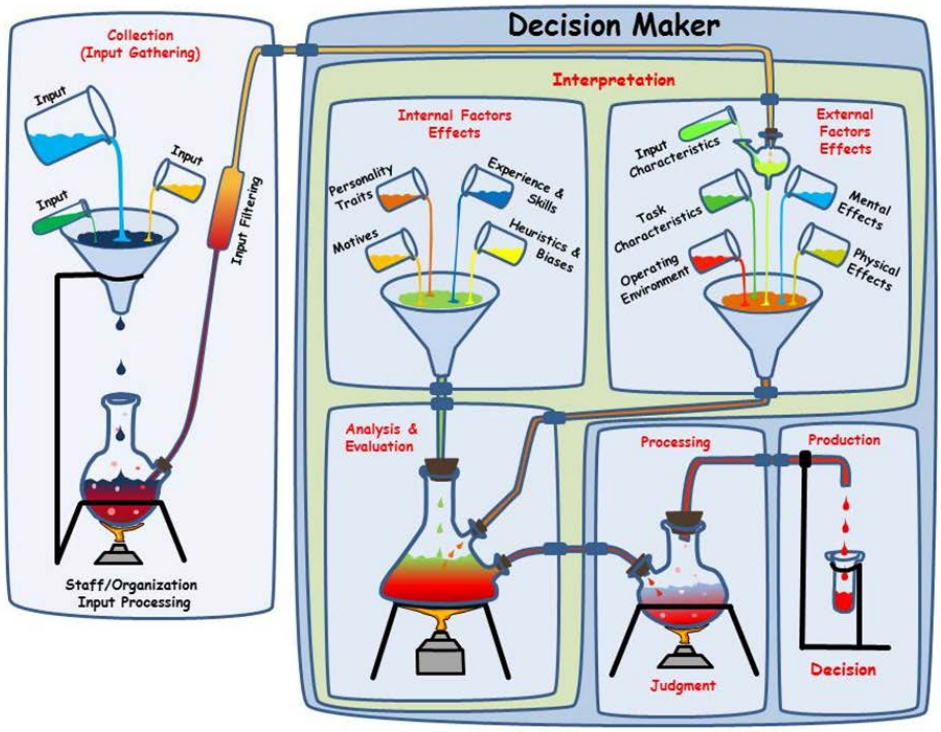

Figure 2. Factors Affecting Decision-Making. For additional detail on this figure, see Appendix A.

Training Needs Analysis Method

To address the question of what instructors/trainers need to know in order to train Soldiers' higher-order thinking skills, we conducted a training needs analysis (TNA). This TNA focused on the training provided to ADA Patriot crews. Like Soldiers in other MOSs, ADA crews face ambiguous situations in which they must keep aware of what is happening and make decisions based on evolving information. Patriot crews evaluate multiple aerial contacts, determine whether they are friendly or not, and assign air defense assets to those determined to be unfriendly. The information used to determine what to do comes from a variety of sources—

e.g., radar arrays, communications with other personnel. An initial plan undergoes continuous revision, given new information and changing priorities.

ADA crews may benefit from training in higher-order thinking skills. Improving these skills may support them in interpreting ambiguous information and making effective decisions in response. Associated with that need is one specific to trainers. Trainers need to know how to train higher-order thinking skills. Currently, trainers receive no instruction on effective ways to elicit and develop Soldiers' decision-making skills for ambiguous situations. Since ADA Schoolhouse training is primarily focused on initializing the Engagement Control Station (ECS)/Information Coordination Central (ICC), air battle operations—where most critical decision-making occurs—becomes the responsibility of unit trainers at the Patriot battalion and battery. While Schoolhouse instructors receive instructor skills training and teach from a standardized curriculum, unit trainers often must devise their own approach to training and certifying their crews.

There appears to be a gap in the preparation unit trainers receive, particularly with respect to training decision-making and problem-solving skills to be applied in ambiguous contexts. To address this gap, a TNA was conducted. TNA is a technique that contrasts desired performance with current performance for individuals and organizations (Miller & Osinski, 1996). TNA helps determine what training is needed to bridge identified gaps (Goldstein, 1993). Sometimes gaps can be addressed with training, other times gaps are due to personnel or material resources (U.S. Office of Personnel Management, 2013). A TNA begins by matching performance requirements to specific knowledge, skills, and abilities. Then, if those knowledge, skills, and abilities are determined not to be present, training can be developed to address the gap.

Developing a Higher-Order Thinking Skills Training Needs Analysis

A review of literature on higher-order thinking skills assisted in identifying the knowledge, skills, and abilities required by trainers to develop trainees' higher-order thinking skills. A list of key skills was assembled. For the TNA, we targeted those skills associated with the cognitive tasks of analyzing, evaluating, and creating, i.e., higher-order thinking skills.

Training Needs Analysis for ADA Patriot Missile Crew Trainers. The TNA identified training needs for unit trainers of Patriot Missile crews. Data were collected from reviews of ADA literature, observation of Patriot missile crew pre-certification training and AARs, interviews with crew certification personnel, interviews with ADA School training personnel, and discussions with Patriot missile crewmembers. Table 2 lists the personnel interviewed and the primary type of information gained for use in the TNA.

Table 2
Sources of Data for the Training Needs Analysis

Source	Number of Personnel	Method of Collection	Information
ADA School Senior Warrant Officer (CW5) - Ft. Sill, OK	1	Interview	Patriot missile crew training, trainer training, common training issues
ADA School Course Managers and Course Directors - Ft. Sill, OK	7	Interview	Training content within various courses
ADA School Instructors (Off, WO, NCO) - Ft. Sill, OK	7	Interview	Training content, methods, and techniques
31st ADA BDE SMEs (Btry Trainer, EMMO/Standardization Off, NCO) - Ft. Sill, OK	4	Interview	Patriot missile crew training, trainer training, trainer status, training methods and techniques
69th ADA BDE SMEs (Off, WO, NCO, Enlisted) (Patriot missile crews & trainers) - Ft. Hood, TX	12 3-person crews (36 total)	Interview, observation of AARs & operations	Patriot missile crew operations, Patriot missile crew training, crew training status
SPEAR Team SMEs (Off, CWO, NCO, contractors) - Ft. Hood, TX	20	Interview, observation of AARs & operations	Patriot missile crew training, crew training status, common training issues

Note: Chief Warrant Officer 5 (CW5), Warrant Officer (WO), Officer (Off), Noncommissioned Officer (NCO), Brigade (BDE), Battery (Btry), Electronic Missile Maintenance Officer (EMMO), Standardized Patriot Evaluation and Assessment Reporting (SPEAR), Subject Matter Expert (SME), After Action Review (AAR).

For the TNA, desired and current trainer performances were examined through a combination of observation and discussions with trainers and senior ADA training personnel. In addition, these personnel helped to identify the specific higher-order thinking skills used in Patriot Crew Operations, which would benefit from additional training. In addition, researchers observed ADA Patriot crews inside the Engagement Control Station as they fought simulated air battles during their pre-certification training as well as the associated AARs conducted by training personnel.

Various techniques can be applied in conducting a TNA (cf. U.S. Office of Personnel Management, 2013; Morrison, 2012; Chand, 2015). Here, the researchers first identified the specific higher-order thinking skills to be exercised during training. Once the key thinking skills were identified, developmental concepts the trainers need to apply were assessed, the factors contributing to the gaps were identified, the training needed to address the gap were determined, and solutions to how that training can be obtained were developed. Figure 3 presents the approach utilized in this research to identify what trainers need to know to develop Soldiers' higher-order thinking skills.

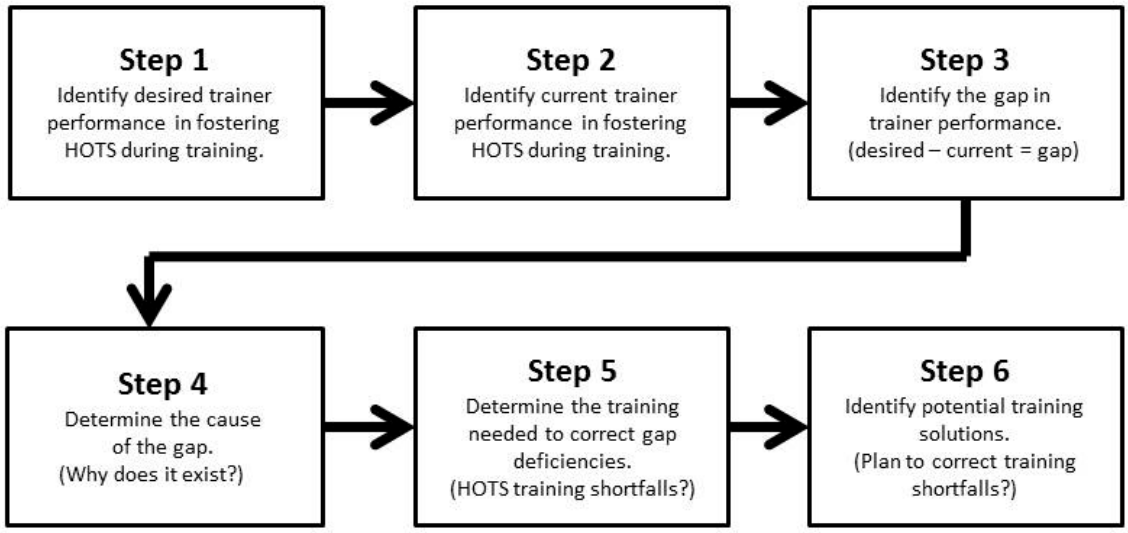

Figure 3. Higher-Order Thinking Skills Training Needs Analysis Flowchart. The HOTS acronym refers to higher-order thinking skills.

Step 1: Identification of Desired Trainer Performance. In conducting the TNA, the researchers first identified higher-order thinking skills concepts that trainers should be implementing during training, including those the trainer should target when delivering instruction. This step included identifying opportunities trainers may use to assist learners in developing their existing critical thinking and problem-solving skills.

Step 2: **Identify Current Trainer Performance.** After specific thinking skills were identified, the researchers observed and interviewed trainers in the classroom. Particularly important was determining whether instructors were putting into practice adult learning techniques to elicit and support development of higher-order thinking skills.

Step 3: Identify the Gap in Trainer Performance. To identify the gap in trainer performance, the researchers compared desired performance with current performance. Where discrepancies arose, targets for additional training were identified.

Step 4: **Determine the Cause of the Performance Gap.** Once gaps were identified, the researchers sought out potential causes. Factors often associated with training gaps for higher-order thinking skills included:

- insufficient trainer preparation for training higher-order thinking skills,
- lack of understanding of how to incorporate development concepts,
- improper use of available training time,
- thinking skills training not designed as part of the training program,
- no value assigned to thinking skills due to lack of understanding, or
- causes beyond the trainers' influence (e.g., personnel or resources).

Additional factors may include student differences, student performance requirements, and training environment factors (e.g., course content, resources, and the flexibility to tailor training) (Dyer, Wampler, & Blankenbeckler, 2011). Figure 4 shows how factors may interact, contributing to the performance gap.

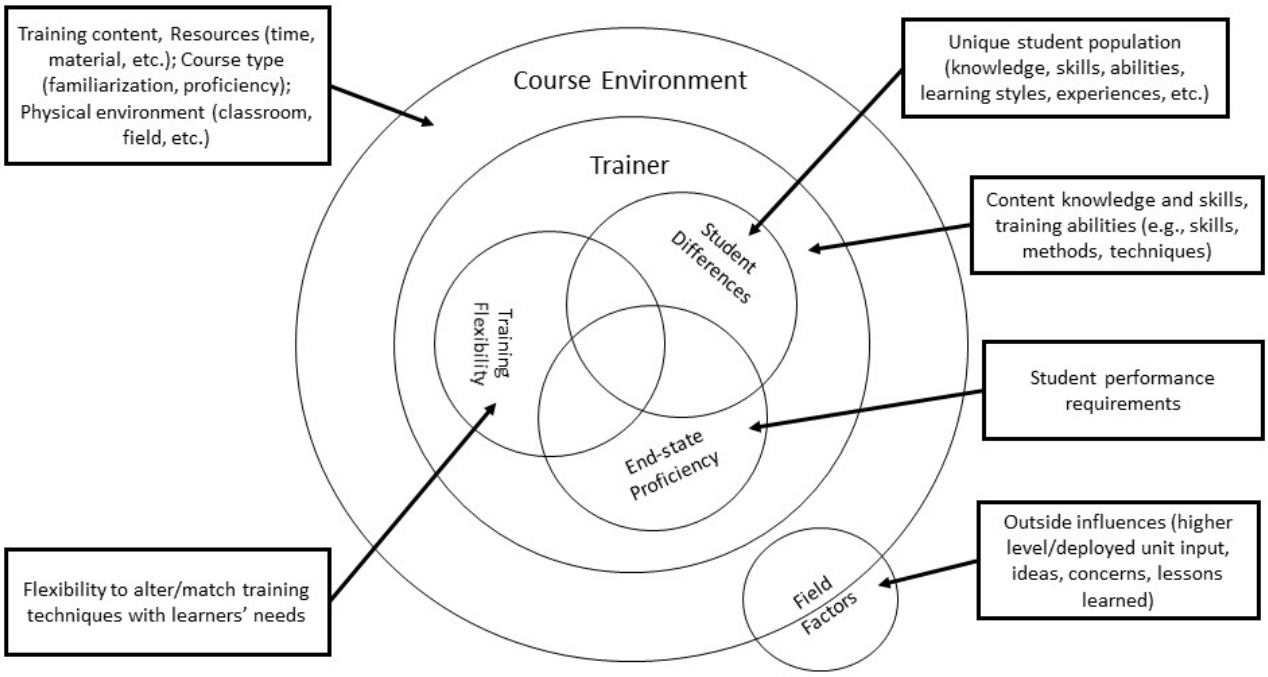

Figure 4. Factors Contributing to a Performance Gap.

Step 5: Determine the Training Needed to Correct Performance Gaps. After causes of the gap were determined to be training-related, training needs were identified. Training needs were targeted in terms of instructional competencies to support trainers in developing learning higher-order thinking skills (Nihill & Stallings, 2014; see also Duron, Limbach, & Waugh, 2006).

Step 6: Identify Potential Training Solutions. The last step in the TNA identified solutions for how to address identified training needs. Those solutions included specifying what training should be provided to trainers, how that training will be given, and where that training will take place.

Training Needs Analysis Results and Discussion

Given the specific content being trained, it is unlikely trainers will need to develop all higher-order thinking skills in learners. Trainers who plan to develop thinking skills in learners may need a training curriculum that includes the following three main instructional competencies:

- ***Higher-Order Thinking Skills Background Information.*** This training would introduce trainers to higher-order thinking skills concepts and their general application to the content domain being taught. This training would include information on cognitive skills, critical thinking, differences in higher- and lower-order thinking skills, why development of thinking skills in learners is important, how thinking skills are elicited, and how to create a learning environment to encourage critical thinking.

- ***Adult Learning Methods and Techniques.*** This training would familiarize trainers with adult learning theory, training delivery methods, and instructional techniques to promote critical thinking and problem-solving. Delivery methods could include collaborative, experiential, exploratory, and/or discovery learning, use of problem-solving scenarios, and other methods that promote the use of critical thinking skills. Instruction on techniques may include facilitation, leading discussions, and effective questioning.

- ***Higher-Order Thinking Skills for Targeted Instruction.*** This training would provide information on how the specific higher-order thinking skills apply to the specific training content presented in a course. The instruction would target how critical thinking and problem-solving skills are applied operationally.

Identification of Specific Higher-Order Thinking Skills

Burns et al. (2006) categorized thinking skills into seven basic categories, which are intended to be generalizable across content domains. Based on the nomenclature presented in Table 1, a list of specific higher-order thinking skills was developed by relating cognitive skills associated with analyzing, evaluating, and creating with Burns et al.'s model. Table 3 presents the results of this synthesis, including descriptions of how and why the selected cognitive skills are exercised (Burns et al., 2006).

Table 3
Specific Higher-Order Thinking Skills

	Specific Higher-Order Thinking Skills		
	Analyzing	**Evaluating**	**Creating**
Meaning	Breaking information into parts to explore understandings, meanings and relationships	Justifying a decision or course of action	Generating new ideas, products or ways of viewing information or concepts
Skills Exercised (How)	Learner breaks information into parts to understand pieces	Learner conducts in-depth reflection, criticism and assessment	Learner uses what was previously known or learned
Skills Exercised (Why)	To identify evidence for a conclusion	To make a decision	To create new ideas and information
Specific Skills and Associated Action Verbs	**1. Determining cause and effect:** deduce, infer, calculate, deconstruct, take apart **2. Comparing and contrasting:** differentiate, discriminate **3. Classifying:** distinguish, select, organize, find coherence, parse, attribute, structure, outline, integrate, separate, differentiate, subdivide **4. Observing and examining:** investigate, focus, monitor	**5. Deciding:** check, coordinate, detect, test, critique, judge, select, choose, justify, debate, verify, argue, recommend, assess, discuss, rate, prioritize, determine, criticize, weigh, value, estimate, defend, convince, support, score	**6. Planning and producing:** generate, design, create, invent, compose, construct, devise, invent, assemble, formulate, combine, originate **7. Predicting:** hypothesize, imagine, propose, forecast

Determining Cause and Effect. This cognitive skill concerns the ability to recognize linkages among events in a sequence. It is also essential to recognizing that later events were contingent on those that came before (Burns et al., 2006).

Comparing and Contrasting. Comparing and contrasting consists of perceiving the relevant features of two (or more) things and determining the similarities and differences between them. Relevant features may be physical (such as size, shape, color, or weight) or less tangible (such as value, beauty, or plausibility) (Burns et al., 2006).

Classifying. Classifying involves determining the membership of a particular object in a group based on characteristics it shares with other objects already in that group. Classifying allows the thinker to work with a large number of individual data points by grouping the data in terms of defining characteristics (Burns et al., 2006).

Observing and Examining. Observing and examining involve using one or more of the five senses to conduct an inspection of an item or event to collect associated data. The data collected supports other higher-order thinking skills. The data collected may be qualitative (e.g. seeing color, feeling hot/cold), or quantitative (e.g., counting occurrences of an event or tracking time) (Burns et al., 2006). In Patriot operations, crewmembers are expected to make engagement decisions based on information that comes to them from multiple sources, including radar and

communications with other command and control elements. Based on this information, they must make sense of what is happening in the battle space and be prepared to evaluate and reevaluate their understanding of the air battle based on changing information.

Deciding. Deciding is a cognitive process in which alternative options are perceived, evaluated, and then one option is selected. Typically, decision-making is a complex process that culminates in taking some type of action that may limit future options. Most decisions are made with the information available at the time, which is often incomplete (Burns et al., 2006).

Planning and Producing. Planning is identifying the steps and actions to be taken to achieve a goal. Producing is the use of existing knowledge to create new knowledge, ideas, or concepts. Inherent to both planning and producing is the creation of new knowledge such as a new plan of action or a new understanding of an existing problem. Planning and producing are both creative cognitive skills, involving critical thinking in the context of visualizing, hypothesizing, and formulating new knowledge, including novel solutions to problems or improved concepts (Burns et al., 2006).

Predicting. Predicting is the skill of using past and present available information to forecast events in the future. While the outcome of future events are never a certainty, understanding causal relationships and the likelihood that two events will co-occur can help predictions be more accurate. As predictions are based on evidence, they tend to be more valuable than guessing. Predictions look for trends in data, i.e., the patterns and tendencies that indicate a likely outcome (Burns et al., 2006).

Application of Training Needs Analysis to ADA Crew Trainers

Patriot missile crews must make quick decisions based on incomplete information when evaluating multiple aerial contacts. While the content domain is primarily procedural, critical thinking and decision-making skills are significant components. The ADA School identified the training environment as not fostering the development of higher-order thinking skills. The ADA School is concerned that trainers may not be specifically prepared to develop thinking skills in ADA crews. With proper instruction, trainers may be better prepared to address these skills when training ADA Crews.

At the ADA School, crewmembers are trained to initialize the system and are familiarized with Engagement Control Station (ECS) and Information and Coordination Central (ICC) van operations with limited experience in crew operations. In practice, unit trainers, predominately the Standardization Officer (SO) and the Battery Trainer in the Patriot missile battery, are responsible for the large majority of crew operator training. Although official modified table of organization and equipment (MTOE) positions do not exist in a Patriot missile battery for the SO or the Battery trainer, the unofficial positions are crucial to a Battery's preparedness for executing Air Missile Defense (AMD) operations. The SO, normally a Warrant Officer, is the chief trainer in a Patriot missile battalion. The Battery trainer, normally a Lieutenant, holds the position of the subject matter expert for all matters related to Patriot missile fire control. The SO, along with the Battery trainer, develops the operations and engagements

(tactics) training program for the battalion, maintains standards, executes training plans, and evaluates the proficiency of the ECS/ICC crews.

The six-step TNA process (Figure 3) was used to examine potential trainer issues associated with the ADA School's concern and potential training solutions.

Step 1: Desired Trainer Performance

The primary mission of unit trainers of ECS and ICC Patriot missile crewmembers is to train the actions required to fight air battles, including Weapons Control and Friendly Protection. Many tasks performed during these operations require higher-order thinking skills. Moreover, Patriot missile crewmembers are required to make time-sensitive decisions using incomplete information while dynamically evaluating multiple aerial contacts. Dynamic evaluation involves both procedural skills and cognitive skills to make sense of incomplete information, changing information, multiple tasks requiring attention, and time pressure. ADA crews require training on both performing technical procedures and how to use thinking skills to perform under pressure with incomplete information.

Interviews with Subject Matter Experts. Information from SPEAR evaluators, senior trainers, and other SMEs was combined with observations of crew operations to identify situations in which Patriot crewmembers would be exercising higher-order thinking skills during operations. In many of the identified Patriot missile crew tasks, the crew analyzes incoming information to draw conclusions. Critical decisions are made after some form of analysis; likewise, planning and predicting include both analysis and decision-making. In Table 4, the higher-order thinking skill associated with the ultimate objective for each of the crew tasks is represented with an "O." The higher-order thinking skill represented with an "X" is associated with where the predominant portion of thinking occurs.

Table 4
Higher-Order Thinking Skills Exercised in Crew Tasks.

	Thinking Skills Exercised **O** – Objective **X** – Predominant Critical Thinking Skill						
	Analyzing				**Evaluating**	**Creating**	
Related Crew Tasks	**Determining Cause and Effect**	**Comparing and Contrasting**	**Classifying**	**Observing and Examining**	**Deciding**	**Planning and Producing**	**Predicting**
Set and revise task priorities		**X/O**					
Classify unknown or misclassified track			**X/O**				
Recognize a developing self-defense situation				**X/O**			
Identify a track for auto engagement or execute a manual engagement				**X**	**O**		
Request/recommend modification of radar search mode and/or area		**X**		**X**	**O**		
Request assistance (i.e. track ID, hostile classification, etc.)				**X**	**O**		
Eliminate/ignore a non-hostile or non-threatening hostile track			**X**	**X**	**O**		
Plan/alert battery or ICC to future actions (reload, maintenance, etc.)	**X**			**X**		**O**	
Predict track separation (multiple ACs, ARMs, ASMs)				**X**			**O**
Predict a likely hostile track or action				**X**			**O**

Step 2: Current Trainer Performance

The researchers identified trainer practices based on discussions and interviews with former SOs and Battery trainers. In addition, observations of current training were conducted. The researchers were unable to witness actual training of ECS and ICC crews by their primary trainers. Instead, the observations focused on crew performance during a simulated air battle operation, a reflection of their training, during crew certification conducted by SPEAR evaluators.

ADA crew training is primarily conducted at the unit level, either in a classroom setting, in a simulator, or in the ECS/ICC van itself. Classroom training focuses on delivery of information in which learners must memorize facts and learn procedures for later application in operations. The training elicits lower-order thinking skills primarily, i.e., remembering and

understanding. Once in the simulator or van, crew training emphasizes application of knowledge and procedures while fighting scenario-driven air battles. The trainer observes various crew tasks, makes on-the-spot corrections, and may provide limited AARs.

ADA crews become proficient through repeated practice, using these training techniques and methods. They learn to interpret information on screens, manipulate switches and buttons, and apply procedural steps. As a result, crews become faster and more accurate with procedures. Trainers reported that they routinely use this method of training and do not focus on exercising higher-order thinking skills. Often, trainers reported that limited time and crew turnover drive what and how they train.

While crews displayed varying levels of proficiency in crew operations when they were exposed to scenarios with increased ambiguity and complexity, their decision-making abilities decreased. In this situation, many crews failed to execute all necessary actions. Planning and predicting actions suffered as well when requirements increased and crew failed to prioritize actions appropriately. The SMEs interviewed noted that even though crewmembers are proficient in procedural actions and system manipulation, they did not always understand the reason for their actions or the overall effect of those actions on operations.

Problems arise during operations when complexity, time-pressure, and incomplete information are present. Under these conditions, ADA crews become less able to identify a proper course of action, take longer to make a decision, and sometimes fail to appropriately plan for future actions.

Step 3: The Gap in Trainer Performance

From the information gathered in Step 2, it was apparent that trainers routinely utilize training techniques that emphasize lower-order thinking skills: remembering, understanding, and then applying information. For the majority of ADA crew training, development of higher-order thinking skills is not an intended part of the design. Trainers are not specifically using adult learning methods to foster critical thinking and decision-making skills required by the operational duties of ECS and ICC crews. Three issues were identified as training gaps:

- ***Higher-Order Thinking Skills Not Fostered During Training.*** The development of higher-order thinking skills in crewmembers has not been designed into the Battery training program.
- ***Adult Learning Techniques Not Used.*** Most training consists of information and procedures to be remembered and then applied. Repeated practice of procedural skills during simulated air battles is the routine method of training. Adult learning methods and training techniques are not used to foster higher-order thinking skills in learners.
- ***Training Focuses on Application of Procedural Actions Without Understanding.*** Some trainers focus on procedural actions without complete supporting information. Crews may more effectively develop decision-making, analyzing, planning, and predicting skills when they understanding the meaning and effect of procedures in the context of operations.

Step 4: Causes of the Gap

Based on interviews with ADA School managers and senior personnel, the researchers explored why unit trainers use the methods and techniques they currently employ. Additional information was provided by schools who instruct Officer and Warrant Officer personnel to become SOs and Battery trainers.

Prior to arriving at a unit, SOs and Battery trainers receive no preparation to be trainers. Formal instruction, such as the Army Basic Instructor Course (ABIC), is required only for personnel destined to be a trainer in school or institutional settings such as at the ADA school. Therefore, unit trainers do not receive in-depth instruction on current Army Learning Model concepts, methods, and techniques. The ADA School prepares Officers and Warrant Officers for their operational duties at an ADA unit, but does not provide train-the-trainer instruction on adult learning methods and techniques.

Prior to attending advanced ADA schooling, WOs attend training at the Warrant Officer Career College (WOCC) in Fort Rucker, AL. The WOCC trains all warrant officers through the Warrant Officer Candidate School (WOCS) and the Warrant Officer Intermediate Level Education (WOILE) course. In a previous effort, Nihill and Stallings (2014) conducted research concerning the use of adult learning methods and techniques at the WOCC. While that effort was designed to assist WOCC instructors in using adult learning concepts at the school, discussions with the Director of Education and Training provided that the instruction given to WOs attending the school did not include train-the-trainer training or information on adult learning concepts.

Personnel assigned as SOs and Battery trainers are similar in that the unit trainer assignment is an additional duty. MTOE authorizations for them do not exist. Often, unit trainers are selected based on who in the unit is the most knowledgeable and experienced in employing the Patriot missile system. Once those duties are assigned, the unit trainers receive no training to prepare them to train crews. As such, they tend to train as they were trained and how previous unit trainers trained.

Discussions with current and former SOs and Battery trainers substantiated that they were often not familiar with higher-order thinking skills concepts and more specifically decision-making as a thinking skill concept. They tended to be unaware of the need to establish higher-order thinking skills as a training objective. As unit trainers were not aware of the need, nor focused on improving decision-making during training, they did not have a clear understanding of how to develop higher-order thinking skills in learners. This gap was attributed to five causes:

- Lack of knowledge on higher-order thinking skills,
- Lack of knowledge on decision-making, planning and predicting,
- Lack of awareness of the need for higher-order thinking skills training,
- Lack of training on adult learning methods and techniques, and
- Lack of training on how to foster higher-order thinking skills during training.

Step 5: Determine the Training Needed to Correct the Gap

To close the identified training gap, trainers will need both informational and application training regarding higher-order thinking skills, adult learning, and the specific thinking skills related to crew operations. Since virtually no training has been provided to unit trainers to prepare them to develop higher-order thinking in learners, they require a curriculum including all three main instructional competencies: higher-order thinking skills background information, adult learning methods and techniques, and targeted information on the specific higher-order thinking skills of decision-making, planning and producing, and predicting—all skills related to evaluating and creating in Table 4.

For background knowledge on higher-order thinking skills, trainers need to learn about cognitive functions, critical thinking, problem-solving, and how these skills apply to job tasks. The training should include a description of lower- and higher-order thinking skills, the difference between the two, and should cover the content and concepts contained in Table 1 of this report.

Trainers will also need to learn about adult learning concepts and theories, particularly how they are applied to promote critical thinking. This training should focus on how adults learn new concepts, skills, and information. Training should include discussions on instructional methods such as collaborative learning, discovery learning, problem-solving, discussions, and practical exercises that promote knowledge transfer. Additional information should be provided on questioning techniques, effective use of learner mistakes, time management, verbal and non-verbal communication, and job application relationships.

Patriot Battery unit trainers will require training on how to train decision-making, planning and producing, and predicting. Much of these skills can be incorporated into training for the decision-making process, as decision-making requires an awareness of the situation (analyzing and evaluating) as well as anticipating effects of the decision after it has been made (planning and producing, and predicting). This training would focus on how the decision-making process works so they can implement instructional methods to foster its development, incorporating these related cognitive skills. At a minimum, this training should consist of an overall description of the decision-making process in adults, the identification of the components involved in decision-making, an understanding of the internal and external factors involved in making decisions, and a general discussion of the interaction of the factors involved. The training should also address how contextual factors can be manipulated to elicit problem-solving, critical thinking, and decision-making skills in learners.

Finally, to provide additional development of planning and predicting skills for crewmembers conducting ECS/ICC operations, trainers will need to learn to create problem-solving opportunities that will drive crews toward having to prioritize actions, predict future contingencies, and plan for known and possible future actions. While necessary and vitally important, planning and predicting are complicating actions that require attention without compromising immediate actions and operations. As a vital part of operations, unit trainers must be prepared to include planning and predicting in their training program.

Step 6: Potential Training Solutions

A variety of training solutions could address the identified training gaps. Considerations for filling those shortfalls may include but are not limited to:

- Participation in available TRADOC Army instructor training courses,
- Training developed and/or offered at local or other training installations,
- Training offered by civilian agencies,
- Army and/or civilian online training courses,
- Army and/or civilian resident and computer-based training, and
- Development of new training to meet the specific training needs.

The feasibility of training solutions should be judged by the trade-off considerations for the resources needed to implement them. Resources may include the availability of the training programs, time away from duties, funding, and equipment. After an analysis of potential training solutions coupled with the availability of resources to implement them, a determination can be made as to how the training shortfalls will be overcome.

Techniques to Enhance Higher-Order Thinking Skills Training

This research sought to determine what instructors need to know in order to train higher-order thinking skills for complex cognitive tasks such as decision-making and problem-solving. The specific group of instructors/trainers we studied were specific to ADA Patriot related MOSs, such as the Master Gunner's Course at the ADA Schoolhouse. Many of the recommendations we make based on our interviews with these instructors as well as more general observations of Army training are intended to be generalizable. The training needs analysis found that overall current training addresses lower-order thinking skills related to remembering, analyzing, and applying information due to an emphasis on mastering tactics and technology related to the Patriot system. Complementary instructor training could support development of learners' skills related to higher-order thinking skills by incorporating additional strategies, methods, and techniques from adult learning theory. In this final section of the report, we identify and summarize particular strategies, methods, and techniques that could be incorporated in Army instructor training generally, and Patriot training specifically, to prepare instructors/trainers for developing the higher-order thinking skills of Army learners.

Instructional Approaches to Train Higher-Order Thinking Skills

An instructional approach combines both the theory and practice of instruction as it is applied to address various learning objectives (Kolb, 1984). It consists of particular strategies, methods, and techniques. An instructional strategy is the type of instruction envisioned for learning activities, focusing on the teaching process and its associated methods for implementation. An instructional method is the way in which learning content is presented. Finally, instructional techniques are the tools used to target learning objectives (Department of Education and Advanced Learning, Government of Manitoba, Canada, 2015).

Instructional approaches are tailored to target the training needs of a particular audience and training content in order to create a desirable learning environment. In selecting an instructional approach, Army trainers should consider how to combine strategies, methods, and techniques to best support students in achieving the specified learning objectives. In doing so, Army instructors/trainers should consider the advantages and limitations of different approaches (Department of Education and Advanced Learning, Government of Manitoba, Canada, 2015).

Instructional Strategies

Having facility in a variety of instructional strategies will enable Army trainers to design learning environments that help Soldiers focus their attention and organize their learning material for better understanding. A combination of strategies may be the most appropriate approach to training higher-order thinking skills (Ministry of Education, Government of Saskatchewan, Canada, 1991). Keesee (2014) described instructional strategies in the following way:

- ***Direct Instruction*** is teacher-directed and deductive, meaning that instruction moves from the general (presenting rules, principles, or laws) to specific examples or activities. It includes methods like drill and practice, explicit teaching or lectures. This strategy is common in Patriot training and in the Army, particularly for Soldiers who are early in their careers. For Patriot, direct instruction could include training focused on the steps required to emplace the system and make it operational.
- ***Indirect Instruction*** is more student-centered, taking into account students' interests. The instructor/trainer's role is more of a facilitator. Examples of this method of instruction would include exploring case studies, guided discussion, or collaborative problem-solving. This strategy is often used with Soldiers as they become more advanced and can rely on their own military experiences when learning new information. For Patriot, indirect instruction could focus on topics related to how to prioritize multiple threats, or fix-or-fight decisions.
- ***Experiential Learning*** is inductive, learner centered, and activity oriented. It focuses more on the process than on the product and utilizes methods such as field trips, experiments, and role-playing. This strategy can be appropriate for Soldiers who have a variety of backgrounds and personal/professional experiences. Experiential learning methods, such as role-playing, could be used to assist Patriot crews in working more together more effectively as well as to learn how to communicate with units in the chain of command beyond the immediate crewmembers.
- ***Independent Study*** methods include computer-assisted instruction, reports, or homework. As the name suggests, it is work that the student does independently, but which may also be done in conjunction with other students. Again, this strategy may be appropriate for Soldiers who have a variety of backgrounds and personal/professional experiences. Patriot crewmembers may collect and read the technical manuals and other literature relevant to their system.
- ***Interactive Instruction*** relies on discussion and sharing among students and uses such methods as debates, tutorial groups, and brainstorming. This strategy may be most appropriate for Soldiers who have gained some knowledge and experience; however, it can be useful at all levels as a culminating exercise following initial instructional and

study. In Patriot, simulated air battles followed by in-depth after action reviews and discussions would be an example of interactive instruction.

For Army instructors, some instructional strategies would seem more suited to training higher-order thinking skills. Indirect or interactive instruction makes use of learners' interaction and collaboration to develop knowledge and skills on their own. Given that many Army learners prefer learning in a hands-on and collaborative context, indirect or interactive strategies may be beneficial for training higher-order thinking skills (Graves, Rauchfuss, & Wisecarver, 2012). These approaches may be particularly effective when followed by a carefully-considered AAR to provide Soldiers with feedback on their performance. For Patriot, scenarios presenting the 10 crew tasks listed in Table 4 could be addressed in training to elicit higher-order thinking skills. Instructors could then guide discussion about crewmembers performance toward issues involving higher-order thinking skills and techniques to improve analyzing and evaluating information, and creating effective solutions to problems encountered in Patriot specific contexts.

Instructional Methods

Instructional methods are the ways in which the learning content is presented. A number of factors guide the selection of instructional methods, for instance, the developmental level of students, teaching goals or objectives, learning content, and environmental aspects such as time, physical setting, and available resources. Most times, a single method cannot meet all learning objectives or accommodate all learning needs. It is for this reason that Army instructors/trainers need to develop a repertoire of methods from which to construct their approach to training (Petrina, 2007). As noted, what often happens in Army training is a focus on repetition that tends to emphasize cognitive skills such as remembering, understanding, and applying. Changing up instructional methods can encourage the development of a broader array of cognitive skills to include those critical higher-order thinking skills outlined in Table 4, i.e., analyzing, evaluating, and creating.

Existing training content can be a vehicle to train higher-order thinking skills. It comes down to how an Army instructor chooses to train content that may elicit and develop higher-order thinking skills. Instructors must purposefully design those opportunities through the strategies and methods they select.

Army instructors should be mindful that they always are training adults and should be knowledgeable about adult learning needs. Research has consistently supported Knowles (1984) observations that adults learn best (a) if they know why they are learning something, (b) when they learn through experience, (c) when the topic is relevant and immediately applicable to them, and (d) when they can view learning as an opportunity to solve real-world problems. The two instructional strategies that most encourage active participation (interactive and indirect instruction) are consistent with Knowles' (1984) observations about adult learners. These instructional strategies also tend to be well suited to eliciting and developing higher-order thinking skills through discussions between learners.

As adult learners, Soldiers benefit from each other's experience and knowledge. Open discussions present an opportunity for Soldiers to become active in learning and to develop

personal contacts with others, contacts that may support ongoing professional development. Moreover, good discussions can be challenging to Soldiers' preexisting beliefs and perspectives, pushing them to formulate new ideas and applications for what they know (see University of California, Los Angeles, 2011). The instructor/trainer acts as a moderator, steering the discussion to encourage in-depth analysis of the content domain. Discussions should have an objective, such as coming up with a solution to a problem, completing a task, or reaching a consensus (Nihill & Stallings, 2014). Ultimately, discussions elicit higher-order thinking skills related to comparing and contrasting points of view, solutions, and reasoning.

Army instructors/trainers may employ a variety of techniques to elicit and develop higher-order thinking skills when facilitating discussions. Often during discussions, learners will move quickly to proposing solutions. The facilitator should seek to extend the problem-solving part of the discussion in order to develop the discussion. Other ways to develop discussions include shifting context and/or points of view, eliciting discussions of costs/benefits, shifting levels of abstraction to further clarify and develop ideas, asking 'what if…' questions, and highlighting points of disagreement in the discussion (see Indiana University, 2012, for additional discussion of facilitation techniques). The following are techniques that may be particularly applicable in an Army training setting.

Cooperative Learning Groups. Cooperative, or collaborative, learning is a method in which students with different abilities form teams to conduct learning activities (Gokhale, 1995). Team members are responsible for both their own learning and that of their collaborators (U.S. Department of Education, 1992). Cooperative learning groups are similar to discussions in that group members offer their own point(s) of view while also considering and analyzing those of others (Westberg & Jason, 1996). Moreover, group members must work together to analyze material, make decisions, solve problems, etc. (Brown & Lara, 2007).

Problem-Based Learning. Problem-solving is an activity in which learners take what they know and apply it to discover what they do not know. Problem-based learning (PBL) encourages critical thinking and problem-solving skills and involves participants confronting contextualized, ill-structured problems and finding solutions by testing hypotheses for satisfactory answers (Major, 1998). In PBL, the learner is given details about a problem and the objectives and challenges are outlined. Additional data is given in which the learner then uses to analyze the situation, determine what happened, and make recommendations.[1]

Problem-solving activities "develop student ability to solve problems using knowledge, concepts, and skills relevant to a course" (McKeachie, 2002). Moreover, problem-solving provides real-world context for learning, which may increase transfer of knowledge from the classroom to the field. Problem-solving methods are student-centered, with the trainer offering guidance as needed. Some useful techniques for utilizing PBL in training are: (a) model a usable problem-solving method, (b) teach problem-solving skills in the context they will be used, not as an abstract skill, (c) help students understand the what and why of a problem first before determining how, (d) budget time to define the problem and understand the goal, (e) ask open-

[1] Levine (1994) provides a lengthy discussion of how PBL may be used to support development of higher-order thinking skills.

ended/what if questions, and (f) link students' errors to how they may be misconceiving the problem (University of Waterloo, 2015).

Brainstorming. Brainstorming is a method that is effective both on the job and in training contexts. When brainstorming, learners offer potential solutions to a problem, regardless of feasibility. All input is recorded initially without prejudice, for subsequent analysis. It encourages a relaxed, informal approach to problem-solving and can result in thoughts and ideas that can be crafted into creative, original solutions.

In training, brainstorming may be used differently than in the workplace. Brainstorming in the training context encourages learners to learn to think creatively and critically. It is by generating and then evaluating ideas that brainstorming can develop critical thinking and other higher-order thinking skills (Bacal, 2015).[2]

Case studies. Case studies are descriptions of unresolved and provocative issues, situations, or questions drawn from real-world events (Crockett & Foster, 2005). Cases challenge adult learners to analyze, critique, make judgments, speculate, and express opinions (Indiana University, 2012). Use of case studies can result in improved retention, recall, and transfer of learning to other contexts (McKeachie, 2002).

To work through a case study, learners are assembled into groups to discuss it and formulate solutions (Brown & Lara, 2007). Case studies give students practice in identifying the parameters of a problem, and help them to recognize and articulate positions, evaluate courses of action, and argue different points of view (Crockett & Foster, 2005). Case studies vary in length, detail, and use depending on the case itself and on the instructor's goals.

Instructional Techniques

Army trainers must learn to implement a variety of instructional methods to foster development of higher-order thinking skills in adult learners. Instructional techniques are applicable across many situations to promote critical thinking and learning. In accord with Knowles' (1984) characteristics of adult learners, five complementary principles for adult learning have been identified (Vandenberg, 1998):

- ***Personal Benefit.*** Adult learners must be able to see the personal benefit of what they are learning, and how it satisfies a need they have.
- ***Experience.*** Adult learners are motivated to learn if the learning involves them in sharing what they know, builds on what they know, and validates their experience.
- ***Self-Direction.*** Adult learners are motivated to learn if they can take charge of their learning and make decisions about the content and process, contribute to the learning of their co-learners, and have some degree of independence in the learning process.
- ***Application and Action.*** Adult learners are busy, practical, and learn by doing.
- ***Learning Styles.*** Adult learners learn best when the learning taps into a mix of learning styles that fit their preferences.

[2] The entrepreneur Richard Branson (2012) has offered a useful discussion of the brainstorming process for those who would like to apply the technique more effectively.

Creating an environment that is interactive, in which learners take an active part in the learning process, helps promote better learning in adults.

Facilitation. Facilitation is an adult learning technique that shifts the focus of the learning environment from teacher-centered to student-centered (U.S. Department of the Army, TRADOC, 2011). The trainer's role is to guide the learning activity, not direct it. Trainers focus on drawing out learners' ideas and experiences. Effective facilitators (a) begin by asking questions, (b) introduce information slowly, (c) make the content applicable, (d) learn from their students' experiences, (e) encourage questions and idea sharing, (f) are clear and direct, (g) allow time for students to think, and (h) keep their own contributions brief (Sunnarborg, 2008).

Effective Questioning. Effective questioning is focused on purposefully structuring and using questions to help students learn, not to determine whether they have learned (Nihill & Stallings, 2014). Questions may be targeting lower- or higher-order thinking skills. Questions asking learners to state, list, name, or describe are focused on lower-order thinking skills; questions asking learners to justify, discuss, convince, differentiate, or defend are focused on higher-order thinking skills.

Job-Application Relationship. Adult learners tend to be motivated by learning knowledge and skills that are applicable to their personal or work lives. Trainers are responsible for creating conditions for learning that highlight the applicability of what is being taught (Keesee, 2011). Adult learners are motivated when they believe they need to learn something new or different (Zemke & Zemke, 1995). Presenting the learning content in applicable, real-world settings helps stimulate learning. Adult learners' level of motivation can be increased if the instructor demonstrates the usefulness of what is being taught, creates a safe environment for the learner, and explores learners' expectations about the learning experience (Goldstein, 2012).

Knowledge Transfer. The idea of knowledge transfer, in simple terms, is when a person takes something learned in one setting (such as in the classroom) and applies that knowledge to a new setting (such as a real-world activity or new situation) (Nihill & Stallings, 2014). For transfer to occur, learners cannot simply memorize information but must also understand what they have learned in order to apply what they learned to other situations (Bransford, Brown, & Cocking, 2000).

In a learning environment, a trainer may reinforce the learning of new material presented by having learners apply the material in a practical exercise. In addition to helping solidify the new material, learners additionally practice the transfer of knowledge as they apply that material to new situations (Nihill & Stallings, 2014). Darling-Hammond and Austin (2003) provide that learners should be allowed to practice transfer in a variety of contexts.

Use of Mistakes. Mistakes made while learning should be viewed as acceptable and positive occurrences, and part of the learning process. Mistakes are valuable tools to foster alternative and critical thinking. Environments where mistakes are viewed negatively can hinder learning. Learners that can identify mistakes and reflect, analyze, and examine their errors are able to improve their understanding and higher-order thinking skills (Nihill & Stallings, 2014).

Mistakes made during training—if they are addressed carefully—can lead to fewer mistakes in practice. This may also assist learners is being able to better predict the outcomes of various decisions they may make and problem-solving strategies they may employ.

Example Instructional Approaches

To develop higher-order thinking skills, Army instructors/trainers need to be able to use the existing course content and training objectives in ways that challenge learners' expectations. A well-designed and executed combination of instructional strategies, methods, and techniques can offer an instructional approach that develops higher-order thinking skills in learners. The following provides an example of how to revise a training approach to better develop higher-order thinking skills.

Military Decision-Making Process Example. An instructor for a U.S. Army resident school is preparing to restructure the training approach for a class on operational planning and the military decision-making process (MDMP). The main objective of the class is to teach the MDMP, a seven-step process, to the personnel in the class. Inherent to the MDMP are analytical and decision-making steps. Currently, the lesson plans include lecture-based classes describing the MDMP followed by a take home practical exercise in which class members apply the process independently and submit their write-up and conclusions to the instructor. The instructor then reviews and provides comments to individuals and selects the best submission to be used as an example to be explained to the rest of the class.

In the revised training approach, the trainer wants to accomplish more in the class than simply having Soldiers memorize and apply the steps. The trainer's objectives include having the Soldiers learn how to critically apply the steps and increase their analytical and decision-making skills. In the revised approach, the trainer plans to use adult learning concepts and methodologies as a way to increase learning and retention, and enhance higher-order thinking skills. The trainer decides to make wide use of the interactive instructional strategy with its associated instructional methodologies and then apply adult learning techniques during instruction. To accomplish those goals, the trainer realizes that some direct instruction is necessary to set foundations but also decides to include the items in Table 5 in the design of the revised training approach to enhance higher-order learning.

Table 5
Characteristics of the Revised Training Approach to Foster Higher-Order Thinking Skills During Training in the MDMP.

Methods and Techniques	**Benefit**
A short video of an Army staff section applying the MDMP to a new mission to begin the class	Use of technology, visual application of material to work related events, sparks interest in learners, portrays why the learning content is necessary
Organize learners into small groups to apply the steps of the MDMP in a classroom setting rather than each learner individually on their own	Variety of opinions shared between learners, learners see other points of views, learners consider and analyze thoughts of others, other views stimulate additional thoughts in individual learners as they broaden their thinking, learners promote learning in others, increased attention to succeed as a group
Make wide use of having questions that are asked during the conduct of the practical exercise to be answered by other students	Learners learn from each other, forces learners to seek out answers rather than simply being told the answer helping to increase retention
The selection of a random member from each group will be required to explain their conclusions along with the results of their analysis and justification that led to the decisions made	Forces critical thinking from all learners, learners must perform analysis of material presented in order to explain the justification of decisions
During presentation of results allow for other groups to ask questions of the presenter	Learners learn from each other, presenters and other learners involved in critical thinking
Facilitate comments regarding the presenter's analysis, justification, and decisions away from criticism and towards critical thinking by allowing for and offering alternative solutions to consider	Makes positive use of less than optimal solutions, allows for critical reevaluation of decisions and conclusions

Other examples. Table 6 provides additional examples of methods of how higher-order thinking skills may be fostered during training.

Table 6
Potential Ways to Foster Higher-Order Thinking Skills During Training

Training example	Potential methods	Benefit
Training combat medics how to identify and treat an injury	Discussion/problem solving – Use the discussion method in conjunction with problem solving to diagnose a hypothetical injury. Instructor facilitates to steer discussion and generate critical thinking and analysis.	Students exercise higher-order thinking skills by combining factual knowledge with analysis and critical thinking to develop alternatives and make decisions.
Training Air Defense system maintainers in an electrical maintenance class how to determine the cause of equipment failure	Problem solving/problem based learning – A simulated event is designed to present students with real world equipment failures in which students must determine the location and/or cause of the issue and the solution for fixing it.	PBL is active as opposed to passive. Allows students to analyze a problem and apply what they know. Analysis of input allows for discovery of what students don't know or need to know.
Training firefighters on how to best attack different types of fires	Brainstorming - Firefighters offer ideas on how to best attack a problem or unique fires. All opinions are recorded and then later discussed and analyzed for pros and cons.	Stimulates alternative thinking, critical thinking, the sharing of ideas and learning from learners.

Patriot Specific Instructional Approaches. Essential to any training that seeks to effectively elicit and develop higher-order thinking skills is an instructor/trainers ability to alter the learning environment. Given the very hands-on and practice oriented approach in Patriot training, the learning environment may be manipulated in a number of ways. In simulations with Patriot crewmembers, for example, instructors/trainers can alter scenarios by incorporating unexpected elements. Examples of critical tasks that can be incorporated into training to challenge learners higher-order thinking skills include: fix-or-fight decisions, establishing or altering task priorities, classification of tracks, requesting assistance, predicting future track actions, predicting track separation, decisions to launch, decisions to execute manual or automatic engagements, and when to execute transfer of control.

Army instructors/trainers cannot directly control the internal cognitive processes of their students. They can, however, elicit and develop these skills by manipulating the external context in which training is taking place. Aspects of the learning environment that can be altered to good effect include the information available to students, the requirements of the task, factors that affect the decision-makers' mental status (e.g., imposing time constraints to induce stress), factors affecting the decision-makers' physical status (e.g., conducting the exercise under mock CBRN conditions), and changing the operating environment (e.g., introduce an unexpected weapons system).

Manipulating Information. Information available to Patriot crews can be manipulated in a variety of ways to elicit higher-order thinking skills. For instance, information from different sources can be combined to augment or contradict particular interpretations of what is happening in the battlespace. Moreover, information flow can be increased or decreased during

a simulated air battle, track data may be altered, or the data feed may be suddenly cut. Each of these events would be unexpected and could be used to elicit and practice higher-order thinking skills.

Manipulating the Complexity of Tasks. Patriot instructor/trainers can manipulate the complexity of tasks to which learners are exposed. This can be accomplished by increasing or decreasing the number of threats the learners must track as well as introducing additional factors that affect decision making such as scheduling launcher reloads or dealing with maintenance faults. The information being supplied to a learner may also evolve in order to create a situation in which crewmembers have to reevaluate their assumptions. This could be accomplished through updating data on a track, changing data for a track (such as splitting a track), reclassifying a known track, providing data that has multiple interpretations, or sending electronic message updates.

Manipulating Physical and Mental Effects. Operating under conditions of fatigue or physical stress can challenge learners' cognitive processes and decision-making abilities. Patriot instructor/trainers can create conditions of physical stress by altering the physical environment, such as increasing ambient noise or altering lighting conditions. Other ways to manipulate this aspect of the learning environment could include conducting a no notice training event, or extending a training event beyond the regular, and expected, time period. Manipulating mental effects can be accomplished by exposing learners to ambiguous situations with a constraint on their time to act, such as creating target saturation on scope with additional hostile tracks from the flank, or a situation in which learners are forced to prioritize their responses to multiple threats.

Manipulating the Operating Environment. Changes to the operating environment can also be effective in eliciting complex cognitive skills. For instance, a Patriot crew could be exposed to changes in the assistance available from outside the Engagement Control Station. For instance, this situation could come about due to communications being cut with command and control elements. Also, a higher level supervisor could be present during an exercise, asking crewmembers questions or giving orders, or a crewmember could be placed out of action during a simulated air battle. Finally, changes to standard procedures, methods, or mandated guidance immediately prior to or during training can force crews to engage in complex decision-making and problem-solving tasks.

When conducting Patriot training, each of these aspects of the training environment can be manipulated to elicit higher-order thinking skills. An effective discussion and after action review would necessarily follow to allow crewmembers to make sense of how they responded to the challenges they were presented with, and identify which responses were effective and which were not. It is during this review and discussion that instructors/trainers can incorporate discussions of higher-order thinking skills and provide feedback essential to improving crewmembers decision-making and problem-solving processes.

Conclusions

General Higher-Order Thinking Skills Training Recommendations

Developing higher-order thinking skills in training should be the result of conscious effort. By increasing critical thinking skills, students can improve their overall problem-solving abilities, decision-making abilities, and general performance. Research has suggested a number of positive outcomes from developing higher-order thinking skills (Foundation for Critical Thinking, 2014). Higher-order thinking skills training can develop learners who:

- raise vital questions and problems, formulating them clearly and precisely;
- gather and assess relevant information, using abstract ideas to interpret it effectively;
- come to well-reasoned conclusions and solutions, testing them against relevant criteria and standards;
- think open-mindedly within alternative systems of thought, recognizing and assessing, as need be, their assumptions, implications, and practical consequences; and
- communicate effectively with others in figuring out solutions to complex problems.

To develop higher-order thinking skills in training, Army trainers must be prepared with the instructional skills and knowledge to accomplish that goal. The TNA designed for this research focused on analyzing the performance of trainers in developing higher-order thinking skills during training. While the focus of the research concerned ADA unit trainers, the results of the TNA and the recommended strategies, methods, and techniques covered in the discussion may be applied by a broad range of Army trainers.

Once trainers are equipped with the knowledge and tools for developing higher-order thinking skills during training, and they have decided what specific skills they wish to focus on, they will need to select the instructional methods they wish to use from among the many available. Creative trainers can find interesting and engaging ways to implement the various methods to help accomplish the objective of fostering higher-order thinking. Appendix B shows examples of how some of the methods may be used to foster specific higher-order thinking skills.

ADA Patriot Missile Crew Training

This research focused on what ADA Patriot missile crew unit trainers need to know in order to develop higher-order thinking skills among the Soldiers they train. Given the time-sensitive and often ambiguous situations in which ADA crews operate, training in higher-order thinking skills may help to reduce the time required for engagement decisions and increase the effectiveness of crews under high-stress situations.

While many of the recommendations may be useful to ADA School instructors, the focus of the TNA was unit trainers. ADA School instructors primarily teach personnel how to initialize the ECS/ICC system and subsequently introduce them to van operations. Unit trainers, predominately the SO and the Battery trainer in the Patriot missile battery, are responsible for the majority of advanced crew operational training where decision-making actions occur. Further, research revealed that in contrast to schoolhouse instructors who receive trainer training through

courses such as ABIC, unit trainers most often receive no formal preparation for their duties as trainers.

This research determined that Patriot missile battery unit trainers must have the ability to determine and implement applicable adult learning techniques and methodologies in the learning environment in order to foster the cognitive processes involved in decision-making. This ability is necessary in order to promote improvement of decision-making skills in learners. To accomplish that mission, trainers require the appropriate knowledge and trainer preparation needed for implementation.

This report is the first in a series of two reports focused on what Army instructors/trainers need to know in order to develop higher-order thinking skills. The second report will present an 8-hour block of instruction that was developed based on the results of the literature review and training needs analysis presented here. In addition, the follow-on report will present the results of validation research conducted using the 8-hour block of instruction with ADA Schoolhouse instructors and unit trainers.

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List of Acronyms

AAR	After-Action Review
ABIC	Army Basic Instructor Course
ADA	Air Defense Artillery
AMD	Air and Missile Defense
BDE	Brigade
Btry	Battery
CW(O)	Chief Warrant (Officer)
ECS	Engagement Control Station
EMMO	Electronic Missile Maintenance Officer
HOTS	Higher-Order Thinking Skills
ICC	Information Coordination Central
MDMP	Military Decision-Making Process
MOS	Military Occupational Specialty
MTOE	Modified Table of Organization and Equipment
NCO	Noncommissioned Officer
Patriot	Phased-Array Radar Intercept to Track on Target
PBL	Problem-Based Learning
SME	Subject Matter Expert
SO	Standardization Officer
SPEAR	Standardized Patriot Evaluation and Assessment Reporting
TNA	Training Needs Analysis
TRADOC	Training and Doctrine Command
USAADASCH	U.S. Army Air Defense Artillery School
WOCC	Warrant Officer Career College
WOCS	Warrant Officer Candidate School
WOILE	Warrant Officer Intermediate Level Education

APPENDIX A

Decision-Making Diagrams

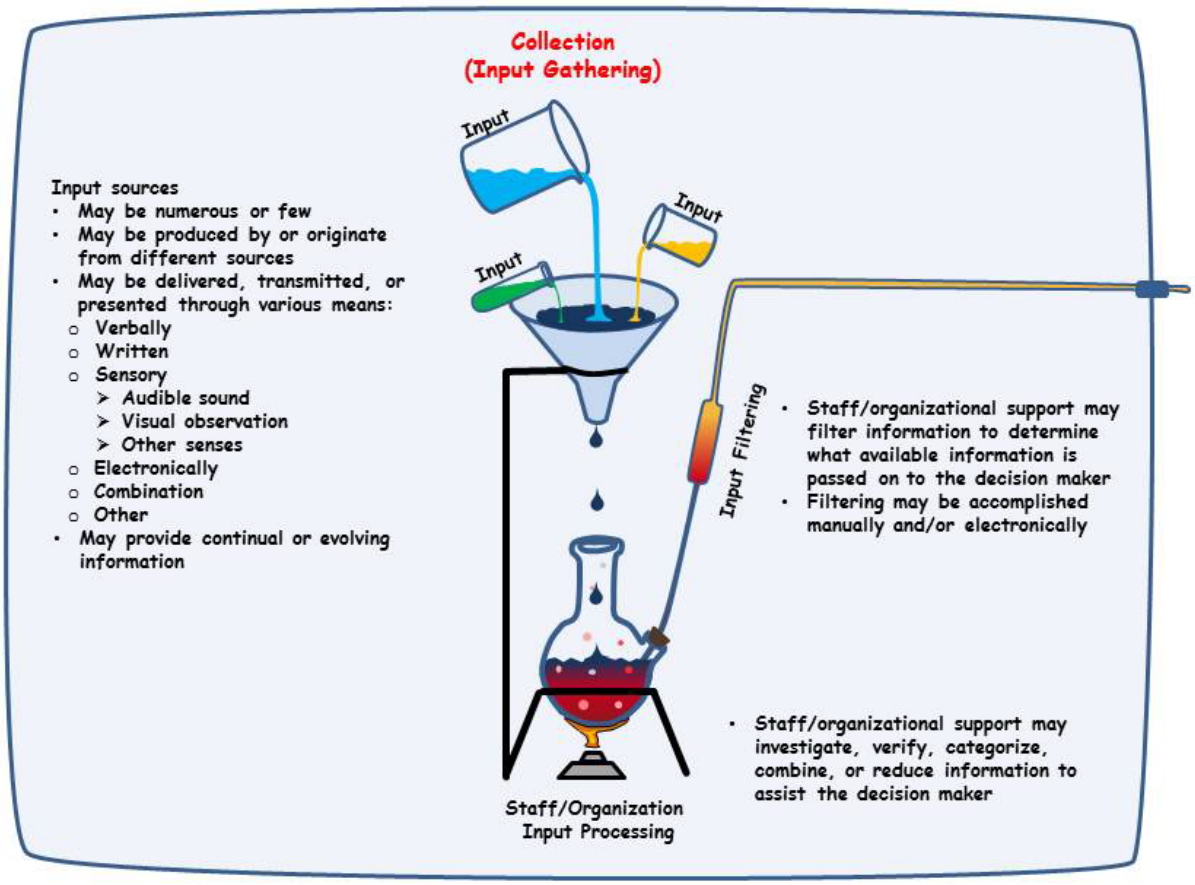

Figure A-1. Factors affecting decision-making - Expanded collection section.

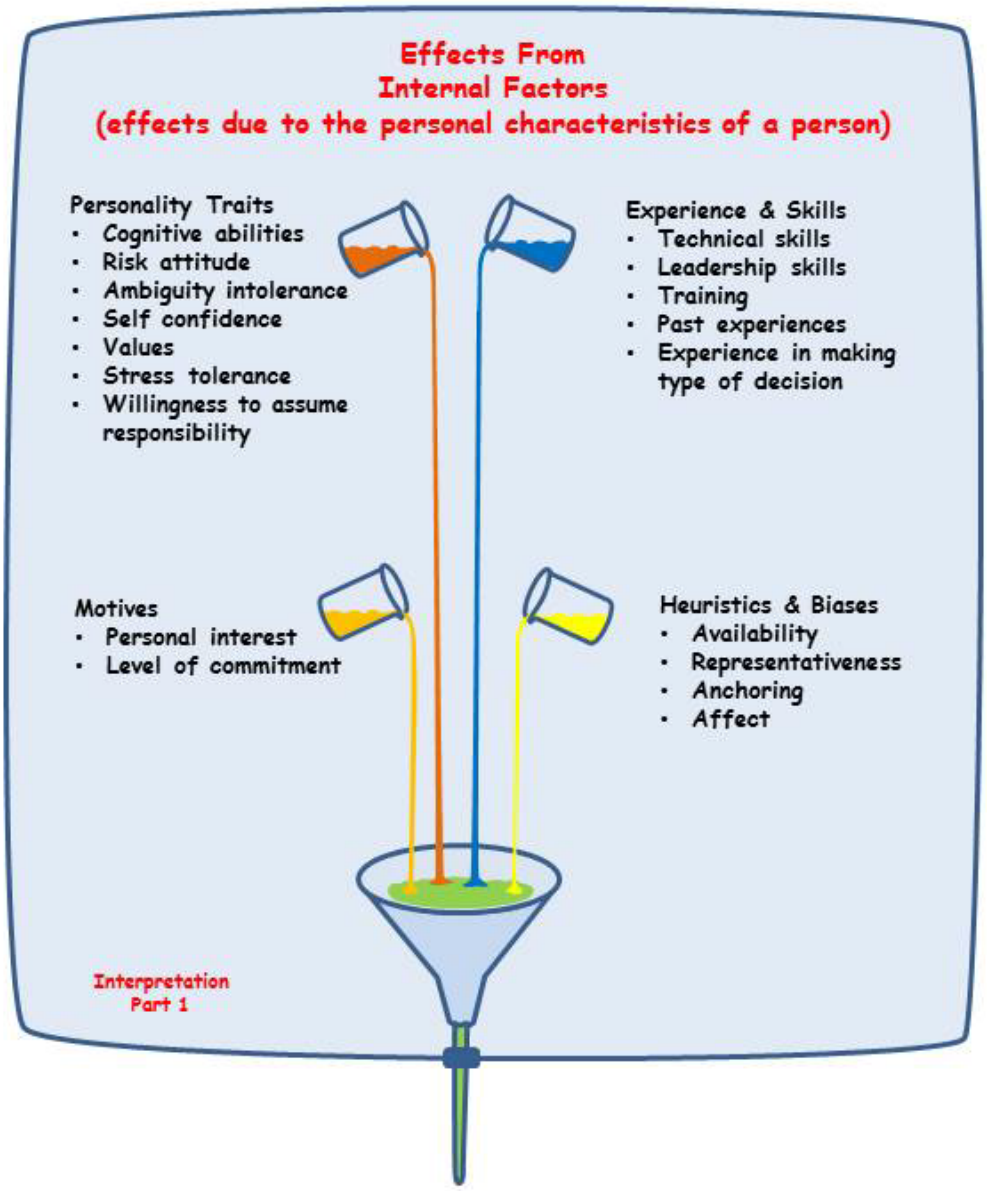

Figure A-2. Factors affecting decision-making - Expanded effects from internal factors section.

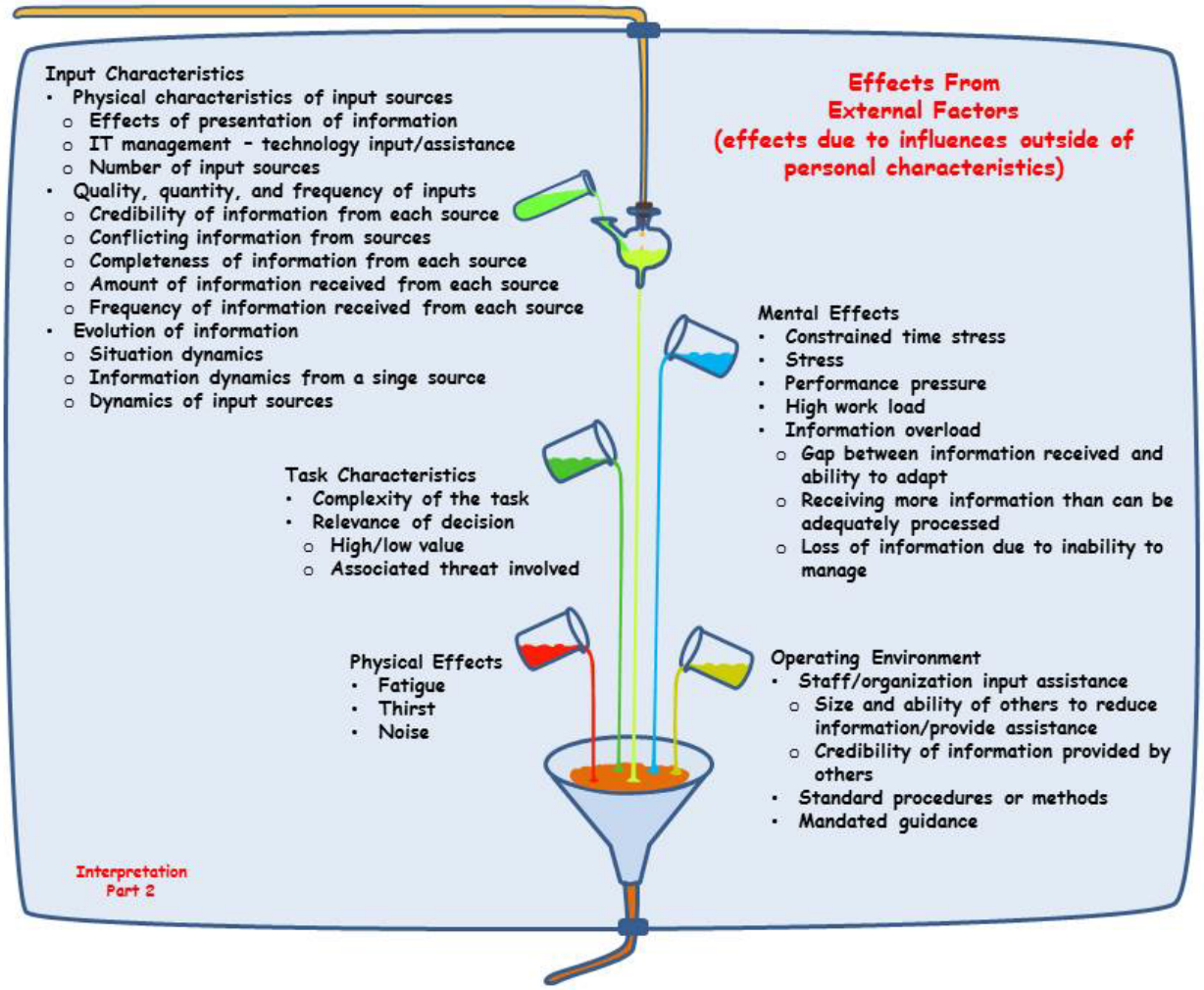

Figure A-3. Factors affecting decision-making - Expanded effects from external factors section.

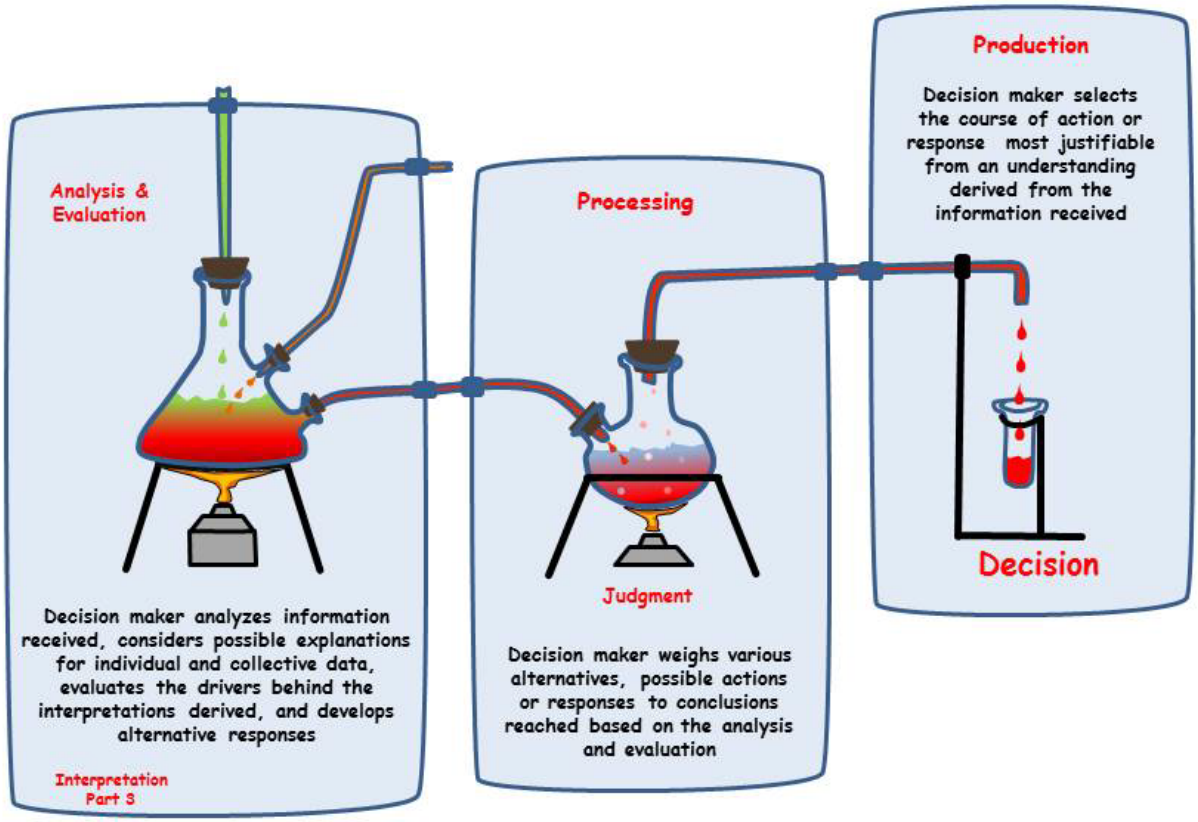

Figure A-4. Factors affecting decision-making - Expanded analysis and evaluation, processing, and productions sections.

APPENDIX B

Methods for Fostering Higher-Order Thinking Skills

Table B-1
Methods for Fostering Higher-Order Thinking Skills.

HOTS	Instructional Method	Description	Purpose	Example
Analyzing, deciding, planning and producing	Cooperative learning groups	Small teams comprised of students of different ability levels use a variety of learning activities to improve their understanding of a subject.	To have students apply theoretical knowledge to real-world problems, or demonstrate decision-making or problem-solving skills similar to those made by professionals in the field.	Students are divided into small groups of five to six people each. A problem situation is given to all groups that require collection of various types of data, analysis of the data, development of alternatives, selection of an alternative, and production of written findings. Have each group share its solution and justification with other groups.
Classifying, analyzing, deciding				Students are divided into small groups of five to six people and each group is given 20 objects. Have each group establish a rationale for its classification, choose five characteristics deemed most crucial to classification, and subsequently classify the objects and justify the decisions.

HOTS	Instructional Method	Description	Purpose	Example
Determining cause and effect	Reflective discussion	A facilitated discussion where participants are encouraged to think and talk about what they have observed, heard or read (McCambridge, n.d.).	To challenge students' thinking by inviting them to interpret, infer, summarize, form conclusions and evaluate selections. To help create analytical thinkers and minds that can work through complex problems.	Show a video or have students read a synopsis of an event with unpredicted catastrophic consequences. Have the students first discuss the effect of the event (what happened); then the cause of the effect (the reason that it happened); and finally the cause and effect (an explanation of why it happened). Subsequently students may offer suggestions of how the effect could have been prevented.
Critiquing, analyzing, deciding	Role playing	A method of learning by exploring issues in complex social situations through hypothetical situations that allows students to practice their new knowledge before application in the real world (Schumann, 2002).	To have student immediately apply content in a relevant, real-world context. Students engage in higher-order thinking by thinking beyond the confines of the instruction setting (Carlton College, 2011).	Introduce students to a problem associated with the training content and have them openly discuss relevant associated issues. Choose two or more individuals from the class to act out a hypothetical, real-world scenario. Give each of the participants associated information for their part in the role playing and have the scene acted out in front of the remaining students. Have an open facilitated discussion of the role players' actions having students critique their performance and offer suggestions and justifications for how they would have approached them differently.

HOTS	Instructional Method	Description	Purpose	Example
Analyzing, evaluating, deciding, planning, predicting	Simulation	Mimicking or imitating an actual, possible, or probable real-life condition, event or situation often involving equipment such as computers, electronic simulators, or actual equipment.	To have the student develop cognitive skills such as reasoning and decision-making while learning the associated technical and behavioral skills for the content being trained.	Have student(s) conduct an exercise on actual or simulator equipment while the trainer and other students observe the actions. Upon completion of the exercise have the participants conduct a review of their own actions followed by peer critiques and suggestions for alternative actions and improvements.
Analyzing, evaluating, deciding	Problem solving	Problem-solving is most often case-based learning where students seek to find solutions to problems. It involves taking what they know and applying it to discover what they don't know (Major, 1998). May include methods such as role playing, simulations, debates, analysis and reflection, and group projects (Blackmon, Hong, & Choi, 2007).	Students are involved in active learning through discussions in order to solve problems or resolve conflicts. Provides opportunities for analysis, proposal of solutions, evaluations, and decision-making (Blackmon, Hong, & Choi, 2007).	Present students with a training content related problem with ambiguous or incomplete data in order to force critical thinking and analysis. Divide students into small groups to search for a solution providing additional information during the progression of the exercise or as requested by group members. Have each group explain its solution to other groups for critical critique.

HOTS	Instructional Method	Description	Purpose	Example
Observing, examining, criticizing, analyzing, determining	Case study	In-depth investigations of a single person, group, event or community (McLeod, 2008). Presented through narratives, situations, data samplings, or statements that present unresolved and provocative issues, situations, or questions (Indiana University, 2012).	To allow students to investigate a topic in detail. Often sheds light on aspects of human thinking and behavior and can help generate new ideas and theories. To challenge students to analyze, critique, make judgments, speculate, and express opinions (Indiana University, 2012).	Present students with a historical example of a training content-related event. Provide details of the situation to include scene setup before the event, additional data and complicating factors associated with the event, actions taken before, during and after the event, and ultimately the outcome. Use questioning and discussion techniques to stimulate critical thinking and promote student discussion. Have students analyze and critique the actions of those involved in the event.
Evaluating and organizing	Concept Mapping	A graphical technique to organize and represent information (Novak & Canas, 2006).	To engage student in actively making sense of and organizing relationships between concepts, ideas, etc.	Provide students with a list of key concepts and have them diagram the concepts in a concept map illustrating how they are related; following this have them compare their maps to those of their peers and explain why they organized their map the way they did.

HOTS	Instructional Method	Description	Purpose	Example
Choosing, evaluating, arguing, criticizing	Debates	A structured contest of argumentation in which two opposing individuals or teams defend and attack a given proposition by presenting and contesting varying points of view with regard to an issue (Cruickshank, Jenkins, & Metcalf, 2011), (McCambridge, n.d.).	To have students consider not only the facts of a situation but the implications as well. To have students think critically and strategically about both their own and their opponent's position (McCambridge, n.d.).	Divide the students into two groups. Choose a debatable issue associated with the training content and have one group jointly research the pros and cons of one side of the issue and the other group research the pros and cons of the other side. Choose three students from each side to conduct the debate. Position the two teams at two separate tables in front of the remaining students. Have the remaining students develop a list of thought provoking questions to be presented for debate. Provide the questions one at a time and give each team a chance to respond.
Planning, justifying, deciding	Brainstorming	Students spontaneously offer potential solutions to a problem, regardless of feasibility, all input is recorded with initially no evaluation of ideas, ideas are evaluated in a subsequent analysis (Bacal, 2015).	Uses students' diverse experiences and encourage all learners: to get involved and think both creatively and critically, to think beyond immediate day-to-day issues, to generate ideas from the group and learn from each other (Bacal, 2015).	Define a training content-related topic for contemplation such as seeking to find a solution to a problem, answering a question, or seeking to invent something new. Present the idea and encourage discussion. Record all responses without prejudice, encourage participation, and allow for no criticism. After a set time limit display all ideas, eliminate bad ideas and critically discuss the remaining ones.

HOTS	Instructional Method	Description	Purpose	Example
Comparing and contrasting, deciding	Discussion	Discussions occur when a group assembles to communicate with one another through speaking and listening about a topic or event of mutual interest (Cruickshank, Jenkins, & Metcalf, 2011).	To stimulate critical thinking and challenge students to think deeply to express their ideas clearly. Students are active in learning with opportunities to formulate principles in their own words and suggest applications of these principles (University of California, Los Angeles, 2011).	Describe a situation where an item must be selected from a choice of two items (such as a potential replacement sidearm for Army Soldiers). Through a facilitated discussion, have the students assemble a list of characteristics for comparison and subsequently identify the pros and cons of each item as compared with the other. Discuss the justifications for choosing the characteristics for comparison.