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Designing Interactive Multimedia Instruction to Address Soldiers' Learning Needs

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14. ABSTRACT *(Maximum 200 words)*:
This report is the second in a series of three, focusing on applying instructional design and tailored training techniques to address the Army Learning Model (ALM) point of need concept. The point of need concept focuses both on the accessibility of information to support the learning process as well as designing learning materials to address individual differences in learners' experiences, background knowledge, and job-specific requirements. Here, we describe the process used and rationale for our approach to developing six IMI exemplars focused on point of need training, including three variations of needs-focused designs: familiarization, core, and tailored training. The IMI were developed for two topics —Adjust Indirect Fire and Conduct a Defense by a Squad— specifically targeting content to the needs of new squad or team leaders. We present our recommendations for developing needs-focused IMI for specific Army audiences. A previous report surveyed existing Army IMI for Combat Arms (Blankenbeckler, Graves, & Wampler, 2013); the final report in this series will present the findings of an experiment testing different IMI variations.

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Finally, we would like to acknowledge other key personnel who supported this effort. Designing and developing IMI required a multidisciplinary team to provide expertise. These individuals included operational researchers, military subject matter experts, educational and psychological researchers, computer programmers, and IMI developers. Each of these participants provided insights from their specific discipline that contributed to our final outcome.

DESIGNING INTERACTIVE MULTIMEDIA INSTRUCTION TO ADDRESS SOLDIERS' LEARNING NEEDS

EXECUTIVE SUMMARY

Research Requirement:

The Maneuver Center of Excellence (MCoE) Directorate of Training and Doctrine (DOTD), Fort Benning, GA, requested research to address how the Army Learning Model's *point of need* concept could be applied in the design and development of interactive multimedia instruction (IMI). A first step in that process was to review and evaluate existing Army IMI, which was the focus of a previous report (see Blankenbeckler, Graves, & Wampler, 2013). The current report documents the process and rationale for how we built upon this foundation to design and develop six point of need IMI exemplars. Additionally, it describes key features of the IMI as well as presents the exemplars. An experimental test of the developed IMI will be documented in a third report.

Procedure:

We documented the process and rationale for the design and development of six point of need IMI exemplars. The six IMI exemplars were organized in terms of the three variations of point of need training—(a) familiarization, (b) core, and (c) tailored training—and had as their main audience, new squad or team leaders. Two topics were covered by the IMI: (a) Adjust Indirect Fire and (b) Conduct a Defense by a Squad. Among the point of need variations, familiarization IMI was designed to provide an overview of a topic, providing greater breadth of information than depth. Core IMI was designed to provide in-depth information on a particular topic. Tailored training IMI was designed to be adaptable to different learners' needs by incorporating depth and breadth of information across multiple learning paths, and providing diagnostic pre- and post-tests. In the tailored training variation, diagnostic test scores were used to provide feedback to learners and to help them select among alternative learning paths, thereby personalizing their learning experience.

Findings:

Point of need IMI is supported by key features that can be incorporated into the design of the instructional methods and content to target different types of learner preferences and needs. First, the audience must be identified and their specific needs determined in order to select appropriate content and examples. Concerning the design of the IMI, content should be organized into sections that focus on a single, narrowly defined topic. Providing links to the different parts of the IMI upfront helps to summarize content and provide learners with a means to navigate through the IMI. Part-task assessment and feedback can be used for sequential tasks to build and reinforce the learners' understanding of tasks. Tailored training techniques can be utilized in IMI outside a learning management system, using relatively low cost implementations in HTML. For instance, pre- and post-training diagnostics with feedback may be incorporated into IMI to help learners make self-aware decisions when selecting content to tailor their learning experience.

Utilization and Dissemination of Findings:

This report presents our findings from the second phase of the Tailoring Multimedia Instruction to Soldier Needs research effort. A subsequent research report will describe experiments with the IMI exemplars whose development is presented in this report. The results of our research have been briefed to MCoE DOTD, 4 November 2013, and have been presented as an information paper for the Henry Caro Noncommissioned Officer Academy at Fort Benning, GA in December 2013; and to the Institute for Noncommissioned Officer Professional Development, March 2014. In addition, the IMI exemplars presented in this report have been transitioned to MCoE DOTD.

DESIGNING INTERACTIVE MULTIMEDIA INSTRUCTION TO ADDRESS SOLDIERS' LEARNING NEEDS

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Introduction

We developed interactive multimedia instruction (IMI) exemplars and applied empirically validated instructional design techniques to address the Army Learning Model's (ALM) point of need concept (TRADOC, 2011a). In this research report, we describe the development process for six point of need IMI exemplars designed to address two topics relevant to new squad or team leaders: Adjust Indirect Fire and Conduct a Defense by a Squad. We also present features of the IMI exemplars we developed, covering three types of point of need training: familiarization, core, and tailored training.[1]

Research Problem

The Army has used interactive multimedia instruction (IMI) to address a variety of training needs. IMI has been applied as: (a) prerequisite training before entering courses, (b) supporting instruction within courses, (c) refresher training, and as (d) comprehensive instruction to cover complete courses (Straus, Shanley, Burns, Waite, & Crowley, 2009; Blankenbeckler, Graves, & Wampler, 2013). IMI combines both auditory and visual media with interactive content, designed to respond to learners' actions. Moreover, IMI is often delivered at a distance using technologies such as computers, tablets, or smart phones (Moreno & Mayer, 2007).

ALM has presented IMI as an essential tool for delivering instruction when, where, and how it is needed; that is, instruction delivered at the Soldiers' *point of need* (TRADOC, 2011a). The *point of need* concept may be understood in terms of matching the right learner to the right information at the right time and place. Within ALM, it is a concept intended to guide the Army in developing instructional materials to address critical learning needs when they most need to be addressed within a learner-centered and life-long learning context (TRADOC, 2011a).

Point of need is often addressed from two perspectives. The first is focused on technologies used to deliver training. This includes training research and interventions that seek to apply technologies across different learning environments (see Swanson, Ratwani, Holland, Zeidman, & Bickley, 2013). The second is focused on issues of instructional design, addressing the question of how best to fit instruction to learners' identified needs. These two perspectives are not independent; instruction must be designed within the possibilities and constraints of a selected learning technology (see Dyer, Singh, & Clark, 2005; Blankenbeckler, Graves, & Wampler, 2013).

Even so, our research was focused on the second perspective. Along with presenting examples from the six IMI exemplars, we will address various issues that arose in our development efforts and explain how we incorporated instructional design strategies to address

[1] A previous U.S. Army Research Institute (ARI) research report detailed our evaluation of existing Army IMI for transition to a point of need format (see Blankenbeckler, Graves, & Wampler, 2013). A research report to follow will detail an empirical evaluation of the IMI we developed.

the ALM point of need concept.[2] While this report describes a specific research effort to develop point of need IMI, the processes and problems we describe may generalize to other situations in which training developers and researchers seek to reuse or develop new point of need, tailored, or adaptive training.

Point of Need IMI Planning and Design

The following section describes our process for developing the six IMI exemplars. It also reviews critical decision points and our rationale for various development decisions.

Selecting a Platform

The first decision we made concerned the appropriate platform for the point of need IMI exemplars. We selected Personal Computers (PCs) with Windows Operating System. While we could have designed for smartphone or tablet platforms, we chose this platform because of its prevalence in the Army schoolhouses. Moreover, given our focus on instructional design over technology, the PC platform would allow for greater flexibility for distribution of the IMI exemplars after they had been developed. At present, smartphones and tablets are not officially sanctioned by, nor uniformly present throughout, the Army; therefore, to design instruction for these technologies may limit accessibility (see Larkins, 2014). Moreover, most existing Army IMI has been developed to run on PCs or laptop computers as their primary platforms.

That said, it is important to consider the role technology plays in delivering training at the point of need. The technology chosen to deliver training influences its geographic accessibility—i.e., the training is available when and where it is needed (Brown, 1997). In the longer term, handheld devices may be useful for increasing access to Army training materials, potentially improving Soldiers' ability to reach-back to the schoolhouse when needed. Due to their limitations in screen size, processing power, etc., it is an open question as to whether handheld devices would be more or less effective for multimedia instruction than PCs or laptop computers.

When considering point of need, it is possible for questions about technology to occupy too much focus. Research has explored whether technology may help or hinder applications of particular instructional designs and techniques (see Bedwell & Salas, 2010; Bower, 2008; Clark & Mayer, 2008; Swanson et al., 2013). In fact, some researchers have claimed "technology matters only to the extent that it may allow new instructional methods" (Mayer interview in Veronikas & Shaughnessy, 2005). A focus on the latest technology without also exploring how it impacts instructional design will not likely accomplish what ALM envisions. There is no sense in promoting technology without considering how to educate and train effectively with that technology (Bedwell & Salas, 2010).

[2] Complete copies of the six IMI exemplars are available from Dr. Rhett Graves at the U.S. Army Research Institute on request: thomas.r.graves5.civ@mail.mil. The IMI exemplars cover two topic areas relevant to new Combat Arms squad or team leaders (i.e., Specialist or Corporal [E-4] and Sergeant [E-5] levels): Adjust Indirect Fire and Conduct a Defense by a Squad.

Moreover, if one takes training designed for one technology and attempts to access it on another platform, the transition can lead to problems. The design and format of legacy training may be ill-suited to newer technologies. Consider, for example, the potential problems arising from disparate screen sizes when training intended for the PC is accessed through a web-browser on a handheld device. Moving between technologies without making appropriate adaptations to the design and format of the media could ultimately undermine learning (see Moreno & Mayer, 2007; Clark & Mayer, 2008).

Three Types of Point of Need IMI

Although the ALM has not specified the particular types of needs learners may have, we focused on the following in order to cover a broad range of potential learning needs: familiarization, core, and tailored training (see Blankenbeckler, Graves, & Wampler, 2013). Familiarization IMI was intended to provide learners with an overview of the topic and resources to learn more, i.e., breadth of information. It would assist learners in gaining an overview of the topic domain, but not a high-level of proficiency. Familiarization IMI was further intended for learners who may need to be prepared for more in depth learning, assisting them in forming a basic understanding of the content domain.

Core IMI was intended to provide only the essential information learners would need to perform a narrowly defined task, i.e., it provided depth of information, with less breadth than familiarization IMI. When designing core IMI, we thought in terms of 'how-to' manuals that present a step-by-step approach to task execution. Again, given that the focus was on point of need, we did not intend the learner to develop a high-level of proficiency. Core IMI was designed for learners who would need immediate support in conducting on-the-job tasks or a quick refresher of previously learned skills. This type of training would not lead to mastery, as the core IMI contained no hands-on performance or sophisticated simulation.

Finally, tailored training IMI combined both breadth and depth of information into multiple user-selected learning paths. It also included pre- and post-training diagnostic assessments with individualized feedback following each assessment. Feedback to learners was based on the results of their pre-training diagnostic assessment. The feedback was intended to help learners identify content areas in which they were deficient and to select an appropriate learning path. After learners completed training, they were able to take the post-training diagnostic assessment and receive feedback, with an option for supplementary training. The tailored training IMI design was intended to meet a variety of learning needs. The diagnostic assessments help learners to be more aware of their specific learning needs and to make reasonable decisions on how to tailor their learning experience to meet those needs. While our approach to tailored training did not make use of cutting-edge technologies (such as computer-adaptive testing), it represents an effective and low-cost solution to enable tailored training in Army IMI.

Selecting Topics for the Exemplars

We considered input from a variety of sources when selecting the topics for our exemplar IMI. The Maneuver Center of Excellence (MCoE), Directorate of Training and Doctrine (DOTD) had expressed interest in new IMI relevant to new Squad or Team Leaders (i.e., Specialist or Corporal [E-4] and Sergeant [E-5] levels). We also considered how much material we would be able to reuse when developing the point of need exemplars. We selected two topics to support the interests of MCoE DOTD and the point of need requirements: *Adjust Indirect Fire*, and *Conduct a Defense by a Squad*. Table 1 provides an overview of the point of need IMI variations by their topics, types, and titles.

Table 1
Six Point of Need IMI Exemplars

Topic	**Type of IMI**	**Title**
Adjust Indirect Fire (Task #061-283-6003)	Familiarization	Engaging Targets with Supporting Fires
	Core	Conduct Immediate Suppression
	Tailored Training	Adjust Indirect Fire
Conduct a Defense by a Squad (Task #071-430-0002)	Familiarization	Prepare Positions for Crew-Served Weapons During an Urban Operation
	Core	Designate and Prepare Urban Fighting Positions for a Javelin Team
	Tailored Training	Conduct a Defense by a Squad in an Urban Operation

The tasks, conditions, and standards for the selected topics, as documented in the *Soldier's Manual of Common Tasks, Warrior Leader Skills Level 2, 3, and 4* (U.S. Army, 2008), are summarized in Table 2.

Table 2

Summary of Selected Tasks, with Conditions and Standards

Task	Conditions	Standards
Adjust Indirect Fire (Task # 061-283-6003)	Given a pair of binoculars, a radio, a compass, pencils, a coordinate scale, a map of the target area, a target to engage within the area, and grid location of friendly troops.	Determine the target location to within 250 meters of its actual location. Transmit the initial call for fire within 3 minutes after identifying the target. Send adjustments within 45 seconds after each round impacts. Enter the fire-for-effect phase using no more than six rounds (initial round plus five for adjustment). Fire for effect within 50 meters of the target using successive bracketing procedures (or creeping fire if danger close by).
Conduct a Defense by a Squad (Task # 071-430-0002)	Given a squad, a priority of work, and locations for crew-served weapons designated by the platoon leader.	Accomplish preparation of a defensive position within the time specified in the platoon leader's order while maintaining security, camouflage, and concealment. 1. Designate fighting positions for squad members. 2. Designate alternate and supplementary positions for squad members. 3. Ensure assigned priority of work is followed by all squad members. 4. Maintain security. 5. Continue work as rapidly as possible. 6. Maintain camouflage and concealment (to include noise, light, and litter discipline). 7. Construct positions properly.

Both tasks described in Table 2 focus on essential infantry fire team and squad leader skills. However, neither task is unique to the infantry; these are Common Skill Warrior Leader Tasks (U.S. Army, 2008). Therefore, they are applicable to leaders who must prepare, organize, or execute combat operations in addition to their unit's primary mission. Given that infantry units may be assigned missions to conduct defensive operations as part of unit security and force protection, we concluded that the Conduct a Defense by a Squad topic was particularly relevant. Likewise, the Adjust Indirect Fire task is also applicable to a broad range of combat operations. Leaders in non-maneuver units may need to employ indirect fires to protect themselves or to engage a target of opportunity. Infantry units must be able to integrate indirect fires and employ combined arms effects in all aspects of offensive and defensive operations.

Adjust Indirect Fire is a Skill Level 2 task focused on the Sergeant (SGT; E-5) fire team leader. [3] The task has received more attention since Army Warrior Training Plan required it to be introduced and trained in the Warrior Leader Course (WLC), and then sustained annually in the unit. While Fire Support Teams (FISTs) attached to maneuver companies or platoons have among their primary duties fire support operations, fire planning and target engagement, the small unit leader may be required to call for and adjust indirect fire without the assistance from a FIST. This contingency can arise due to their mission or their location on the battlefield. Adjust Indirect Fire is an individual task, performed by one Soldier.

The Conduct a Defense by a Squad task is Skill Level 3, focused on the Staff Sergeant (SSG), squad or section leader; it is also applicable to the Corporal, Sergeant, or fire team leader. The Army Warrior Training Plan indicates that this task will be trained initially in the unit and then sustained annually. Leaders develop and implement defense and force protection, as well as provide plans for security. These plans and fires must be coordinated with adjacent units. Moreover, leaders who are preparing and executing these plans must often oversee subordinates to coordinate the various tasks involved. A plan must be developed to position units or individual weapons or teams, improve positions, integrate fires, and assure depth and mutual support. Of note, an essential condition of this task is the availability of a squad of appropriately armed and organized Soldiers. These Soldiers must occupy positions selected or designated for them, have these positions and fields of fire verified or adjusted by leaders, improve the positions for survivability and lethality (by improving fields of fire), and prepare to execute mutually supporting fires and actions to destroy the enemy or repel an attack.

We also selected these two tasks because of differences in task attributes and performance. For example, *Adjust Indirect Fire* is a sequential task, with a standard procedure for actions taken to request indirect fires on a target. Executing that procedure also requires some proficiency in map reading. Radio calls for fire are normally communicated in three transmissions with standard information in each transmission. When a target is not located precisely, the impact of rounds is corrected using deviation corrections to the observer-target line and the bracketing method for range adjustments. Bracketing is normally accomplished by successively firing over (beyond) or short of the target, reducing in a methodical manner the distance between subsequent round impacts until the threshold for "fire-for-effect" (normally rounds impacting within +/- 50 meters of the target) is obtained. After "fire-for-effect" the observer reports the effects on the target, continues adjustment or provides target refinement information, and then ends the mission. While there are variations to this sequence based on the enemy target, desired mission type, or proximity to friendly troops, most missions requested by a small unit combat leader follow this sequence.

[3] See Soldier's Manual of Common Tasks, Warrior Leader Skills Level 2, 3, 4 (STP 21-24-SMCT), September 2008. Enlisted MOSs in the Army have associated skill levels. These skill levels relate to a Soldier's paygrade as well as the expected difficulty of duties or tasks to be performed, and the range of managerial and supervisory duties to be accomplished. For example, Skill Level 1 is an entry-level position requiring the performance of tasks under direct supervision. This skill level consists of all Soldiers in the ranks of Private (E-1) up to Specialist or Corporal (E-4). Skill Level 2 is a position requiring the performance of more difficult tasks under general supervision. Soldiers reach skill level 2 when they are promoted to Sergeant (E-5). In many instances, a Sergeant will supervise Skill Level 1 Soldiers.

In contrast, *Conduct a Defense by a Squad* tends to be more cognitive than procedural. It involves selectively perceiving relevant aspects of the battlefield context, understanding the assigned mission(s), and being able to apply basic fire control principles in that context. For example, the leader prepares and plans for the task using Troop Leading Procedures (TLP) and Principles of Fire Control. The steps of TLP are not rigidly sequential. Some steps may be omitted or overlapped with other steps. In support of TLP, mission analysis is guided by factors such as mission, enemy, weather, terrain, availability of troops and support, time, and other civil considerations. No two missions are alike. So, even though the process for establishing primary, alternate, and supplementary positions for units may have similar characteristics, the specifics of TLP, Fire Control Measures, and other position preparation considerations are needed for the defense task. The leader must know the capabilities of the squad's organic and supporting weapons, apply principles of fire control, apply reasonable tactical judgments, execute assigned occupation and preparation tasks in priority, and employ appropriate aspects of mission command in planning, preparing, executing, consolidating, and recovering from the mission.

Another reason we selected these two tasks was based on the availability of viable IMI source materials that we could reuse in developing the exemplars. Information pertaining to the material selected for reuse is provided in Table 3.

Table 3
Selected Tasks and Existing IMI Relationships*

Base Task	**Existing IMI**	**Proponent**	**Source for Files and Materials**	**Delivery Media for Existing IMI**
061-283-6003 **Adjust Indirect Fire**	061-C01-1067: **Conduct an Immediate Suppression Mission** (with embedded enabling Skills and Knowledge - **Call for Fire** and **Subsequent Corrections**)	Field Artillery School, FCoE	FCoE DOTD	CD-ROM; AKO via the My Training Tab Site, 061 Field Artillery School Knowledge Center, and over the web from the FCoE Reach Back/Reset Training
071-430-0002 **Conduct a Defense by a Squad** with added conditions: Urban operations; position/reposition /control crew-served weapons (Javelin and M240B Machine Gun)	071-326-0550: **Prepare Positions for Individual and Crew-Served Weapons During an Urban Operation**	Infantry School, MCoE	Iowa Army National Guard Distributed Learning Development Center	AKO via the My Training Tab Site, 071 Infantry School Knowledge Center

*Note: FCoE is Fires Center of Excellence; MCoE is Maneuver Center of Excellence; AKO is Army Knowledge Online.

IMI Design Process

Army guidance outlines an extensive planning and development process required for most IMI projects (see U.S. Army Training and Doctrine Command Pamphlet, TRADOC Pam 350-70-2; TRADOC, 2003). We used this basic process to guide our development efforts, adapting the process as necessary to incorporate existing IMI and to work around various problems we encountered. In selecting topics and operationally defining point of need, we considered MCoE DOTD's interest in new squad and team leaders. In fact, clearly defining the intended audience was essential to determining the needs we were going to address with the point of need IMI. Defining the intended audience at the outset helped to ensure IMI design and content were appropriate.

Point of need training requires specificity (Blankenbeckler, Graves, & Wampler, 2013). A point of need design seeks to identify and meet specific learning needs. It does so by focusing on the learning needs of an identified group (i.e., new squad or team leaders) and the unique background knowledge and experience of individual learners within that group. Past IMI seems to have been developed to meet the training needs of the largest possible audience. When the audience is defined too broadly, some learners may find IMI contains too much or too little information and others may find that the IMI content is confusing or uninteresting. Point of need IMI is designed to target specific individual and group learning needs in order to keep the training as succinct and focused as possible for each learner.

The target audience was identified as future fire team leaders and squad leaders. On this basis, we determined that the training could build on experiences and knowledge the audience would have gained from deployments, in-unit training, and home station training. Although much reset training over the past 12 years has focused on Southwest Asian missions, this training is now emphasizing decisive operations in a high multispectrum threat environment involving maneuver and combined arms integration. On this basis, we determined that the IMI should depart from counterinsurgency and security operations, and instead deal with sophisticated mechanized threats and enemy forces with parity in equipment capabilities and combat potential (see ADRP 3-0, Department of Army, 2012).

Reusing Parts of Existing IMI

We sought to reuse parts of existing IMI to evaluate whether reuse is a plausible strategy to address the ALM point of need concept, transforming existing Army IMI to fit the new model. Despite being SCORM compliant, the existing IMI proved to be challenging to reuse, a finding mirrored in similar efforts (see Shanley et al., 2009). In fact, Shanley et al. (2009) found that for most organizations, significant returns from IMI reuse were exceptions. Most organizations in the Shanley et al. study reported significant technical issues and unexpected problems arising in their IMI reuse efforts.

Previously we reviewed Army Combat Arms IMI to determine if existing source files (graphics, images, programming, etc.) could be adapted to a point of need training format (see Blankenbeckler, Graves, & Wampler, 2013). We concluded that the approach is possible and the

Army would likely invest more time and resources to reuse existing IMI than to develop new IMI. All the IMI we reviewed needed new content to address the point of need variations we were targeting. It was not a plausible strategy to simply redesign and repackage existing content. As an estimate, new content accounted for about 70% of the total content used in our IMI exemplars for this study. Only about 30% of what we developed was able to use unmodified content of existing IMI.

For example, the Adjust Indirect Fire familiarization IMI lesson adapted elements and extracted pieces from existing IMI, FCoE 061-C01-1067 Conduct of an Immediate Suppression Mission. The elements selected for reuse came from three topics within the existing FCoE module. Minor changes to narration and on screen text were required to meet doctrinal accuracy. Some outdated images were replaced with action images showing Soldiers in current Army Combat Uniform. All materials unique to digital calls for fire were deleted to better conform to the conditions of the common skill task. Much of the existing material was developed using VBS2 video.[4] With few exceptions, these videos and animated segments were maintained and integrated into the training. This lesson provided the highest reuse of existing materials with 28 of the 29 storyboard frames being derived from existing IMI. Only limited image replacement and on screen text corrections were required and these were simplified by the availability of source files for the original materials.

Similarly the familiarization IMI lesson for squad defense reused portions of existing IMI from MCoE 071-326-0550 Prepare Positions for Individual and Crew-Served Weapons During an Urban Operation. Only two topics from the existing lesson were incorporated in their totality. These existing materials adequately addressed what to do to prepare a "selected" crew-served weapon position. Additionally, 11 existing images were drawn from the lesson and reused in the newly developed IMI. However, the logical foundation and underlying rationale that leaders need to make position selection decisions for crew-served weapons could not be located in any existing IMI. Topics focusing on training leaders (e.g., determine fields of fire requirements and implement fire control) were missing from this lesson. Therefore, the topic, Selecting Weapon Positions and Controlling Fires, was included in the new IMI. While we had to develop new IMI for the second topic, Common Preparation Considerations, we made extensive use of existing imagery as well.

For the core IMI lesson for Adjust Indirect Fire, we adapted the tutorial from the lesson, Conduct of an Immediate Suppression Mission. However, to meet the instructional need of addressing "step-by-step task execution," revisions were required to the existing materials for doctrinal accuracy, including narration, images, and internal navigation. These revisions included:

- A more complete learning objective and explanation of the purpose of the mission type.
- Addition of doctrinally correct map graphics to supplement the threat aspect of the scenario.
- Additional materials to explain map grid accuracies and required elements of the call for fire transmission.

[4] VBS2 is the Virtual Battle Simulation Software manufactured and copyrighted by Bohemia Interactive Simulations. It is used by the Army as a tool to simulate various tactical scenarios.

- Supplemental information on target description to enhance initial effects on target.
- Supplemental information on "direction to target" data, computing the "observer target" distance, as well as obtaining and converting mil angle measurements should adjustments be required.
- Development of a review of the core knowledge and skills for executing the mission.

The core IMI lesson for defensive skills reused some images from existing materials. However, other than adapting the eight images from existing materials, the 73 pages of the lesson, Designate and Prepare Urban Fighting Positions for a Javelin Team, were developed anew.

The comprehensive tailored training IMI lessons proved the most challenging to develop. New developmental materials were required for both the assessments and the comprehensive training. The content was framed in tactical situations to facilitate a problem-centered approach, helping learners to increase their understanding through solving concrete problems (see Hmelo-Silver, 2004). Some existing familiarization and core materials were integrated into the tailored training IMI. Of note, these topics focused on narrow knowledge or skills sets, identified as deficiencies through the pre- or post-training assessments. The pre- and post-assessments were also problem centered and were developed to address each step and sub-element of the particular task. While the media imposed some constraints to examining the full task, efforts were focused on replicating what the Soldier would observe, experience, or perform within media capabilities, to provide a rigorous part-task assessment. All assessments were conducted in the context of solving a real-world problem in a tactical scenario. For example, in the Adjust Indirect Fire tailored training IMI, the user was required to initiate indirect fires against and adjust onto a target of opportunity. Figure 1 provides a typical assessment storyboard illustrating features of the assessment design and assessment of skills required for one of the task steps. While the user was provided multiple choice responses to select from, there were no easy exclusions. In the Adjust Indirect Fire IMI, the user selection normally provided only one correct response, while the Conduct a Defense by a Squad tailored training IMI provided multiple correct answers.

We experienced various constraints when repurposing existing IMI, including: (a) unavailable or incomplete source files, (b) incompatibility of archived files with current software, (c) outdated doctrine and graphics, (d) revisions to computer code propagating unintended errors in the existing programming, and (e) difficulties separating the existing IMI from its interface with a learning management system (LMS). Each of these constraints could make any development effort very costly with regard to time and other resources, thereby limiting any effort to transform or repackage existing IMI for point of need. However, we developed some workaround solutions to address these issues. For instance, segments of video and audio can be recorded from existing IMI training without any major loss of resolution (i.e., digital to digital) if the source code is not available or if modifications at the level of source code are not required. These sampled portions of existing IMI may then be incorporated as piece-parts in a new IMI training module. While this is clearly not an optimal solution, it is a field-expedient solution that is inexpensive and effective.

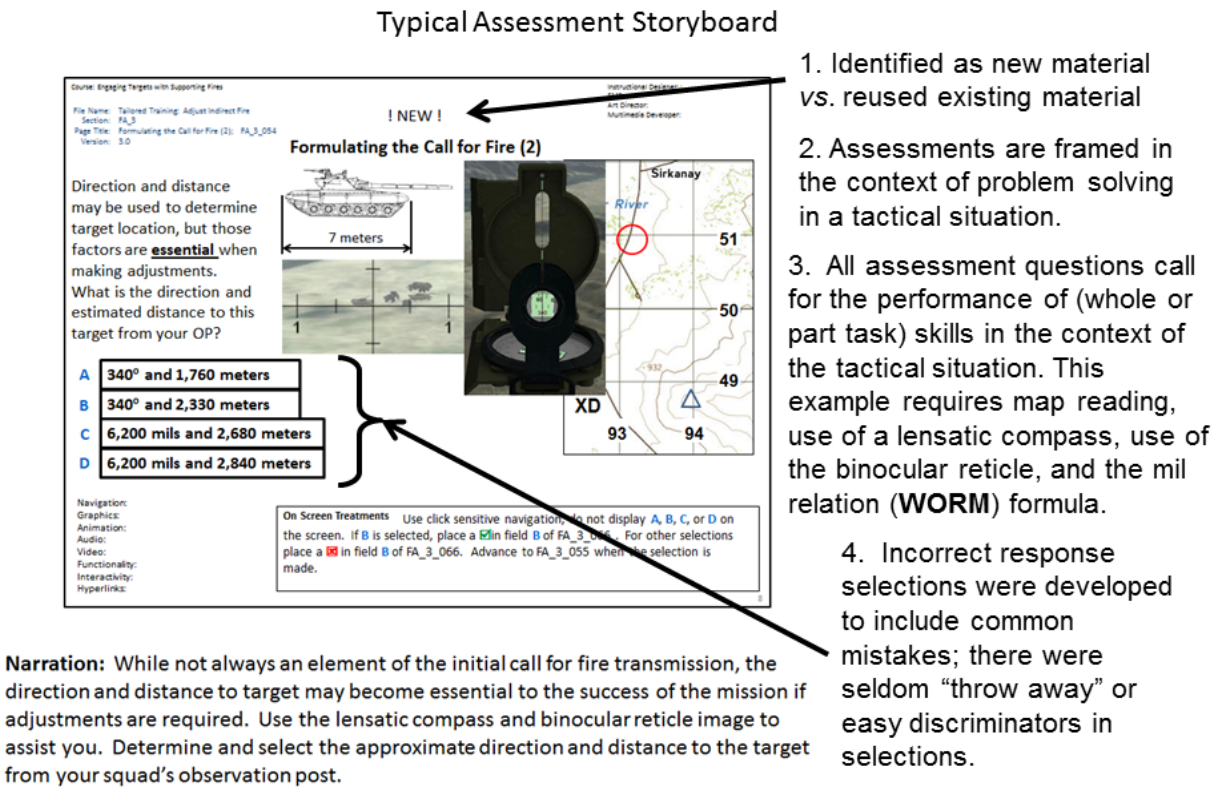


Figure 1. A typical assessment storyboard annotated to highlight some of the instructional design features.

The difficulties involved in reusing existing media are significant in that the Sharable Content Object Reference Model (SCORM) was intended to make training materials portable, durable, and reusable (DoD, 2011). [5] In many cases, problems arise that interfere with the reusability of existing content. The components, identified as Sharable Content Objects (SCOs), reside in the media and in the source files used to construct the media. We were only able to reuse SCOs when they were available or extractable from the existing media. Extracting material (i.e. graphics, video, narrations, etc.) means repurposing its current use as existing programmed media or obtaining it through existing source files.

Source files were not always available. As course proponents have shifted, responsible officials and staffing have changed. Archival files and records, including source files, are not always transferred, retained, or maintained. If retained, they may no longer be available in a form that permits retrieval, modification, or further sharing. These are significant problems that undermine the Army's efforts to operate in accord with the SCORM approach.

[5] SCORM is a standard for a technical framework to enable the use of Web-based e-Learning content across multiple environments (e.g., LMSs). SCORM defines how individual instruction elements are combined at a technical level and sets conditions for the software needed to use the content. For further explanation, see "SCORM 2004, 3rd Edition" (DoD, 2008).

When source files were available, the legacy software used to create those files was frequently not compatible with current versions, necessitating various workaround solutions. Most commercial software companies strive to maintain some backward compatibility in successive releases of their software. However, the market segment for these companies is very competitive, so they have strong incentive to innovate new features and capabilities. The version of software used to program an existing IMI module may no longer be identifiable, technically compatible with newer operating systems, available on the market, or supported in current versions of the software.

Similar compatibility problems can arise when existing IMI is extracted from an LMS.[6] An LMS is a software application designed for the administration, documentation, tracking, reporting, and delivery of e-learning courses and training programs. It is a critical element in the mass distribution of e-learning courseware and defines the communications between the client or learner and the host system. Within the IMI, an LMS defines the learning path for the learner and assures their compliance with course requirements. When course materials are extracted from the LMS, it is important to keep in mind the points at which the host LMS and the hosted media intertwine may act like a software virus, blocking or masking desired functions. Finding these intersecting points in the source code and removing them can be very challenging, since no two LMSs work exactly the same way. Moving materials from one LMS to be reused in another may introduce a number of technical challenges that often can only be resolved by an expert programmer.

Other problems can arise once source content is modified for reuse. Revisions to the programmed instructional media made during development may employ techniques to obscure or mask undesired functions or content. When revisions are handled in this way, the error remains packaged in the media but is now obscured by new material, programming techniques, or has been adjusted to display and run in the desired manner. When working with the source files to extract a section of IMI for reuse, these hidden problems can interfere with the process. Given these issues, developing IMI from anew may be the better alternative in terms of time and cost.

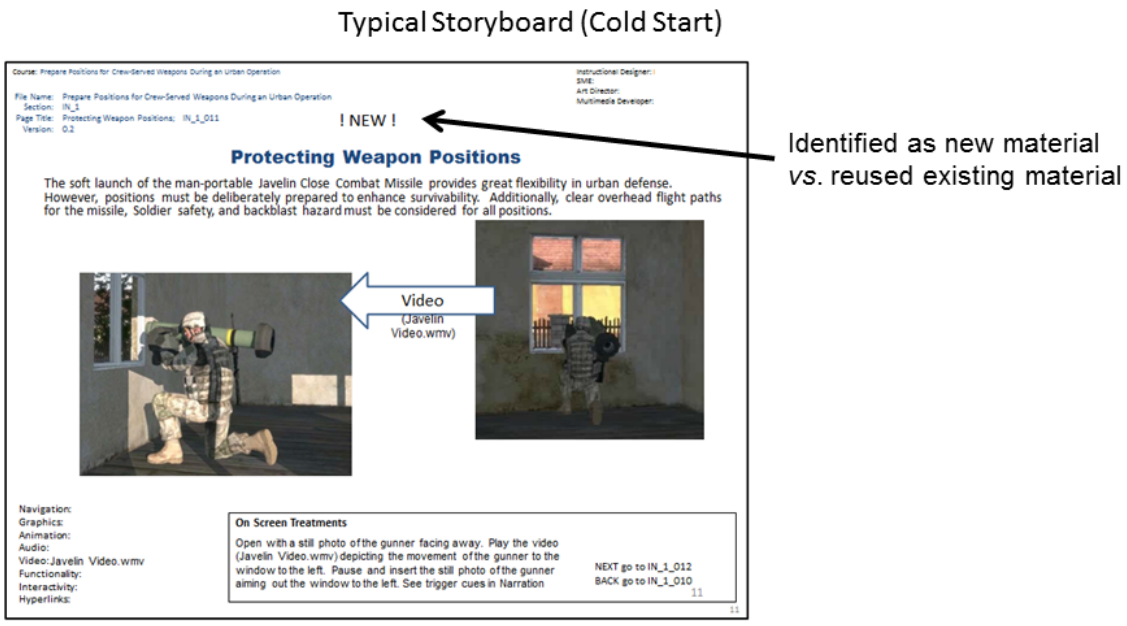
Storyboard Development

Our storyboard development process was intended to accommodate both reused and newly developed IMI materials. While new material could be developed to accord with our selected pedagogical approach, the existing materials we selected would also need to mirror that approach. While our desire was that existing materials could be used as is, most had to be revised to ensure continuity between our pedagogy and instructional design. Further, we recognized that we needed to ensure that correct doctrine was being presented in order to meet desired learning outcomes. A number of images and narrations from existing IMI had to be revised to be accurate and current, especially in regards to reflecting current uniform combinations and equipment. It was critical to avoid any compromises concerning tactics and doctrine. If these conditions could not be met, the materials were not reused.

[6] LMSs employed by the Armed Forces must meet high standards and specifications for web-based e-learning and must be SCORM compliant.

Instructional designers used a storyboard format common to the traditional IMI development process. In particular, Microsoft's Office 2007 PowerPoint note pages were easily adaptable to this task. The note pages served as a workbench for assembling the required elements the designer, reviewer, and programmer needed to approve and build the IMI. While programming may combine the elements of multiple storyboards, a storyboard represents a single unit of the media and should provide:

- Administrative reference information – file name, page number, edition, as well as information to identify key members of the production staff or principles.
- On screen text.
- Visual media display data – graphics, photographs, tables, animation, and video segments.
- On-screen treatments, programming, triggers, controls, and user interface details for actions on the page.
- Primary navigation information for forward progression or returning to previous pages.
- Secondary navigation and action information for automatic, conditional, or user selected options such as branching.
- Narration, dialog and sound effects.
- Scoring or desired feedback from user interface, selections, or actions.



Narration: (Open with still photo of gunner facing away) In this example, a Javelin team has a primary position with a sector of fire oriented on (**say letters**) T R P two to the north, (play video) but the gunner can quickly shift to a supplemental position. The supplemental position has a sector of fire oriented on (**say letters**) T R P one to the west (stop on still oriented left). Since the anti-tank systems are priority targets for the enemy, both positions must be improved to enhance survival. Additionally, backblast hazard, safety of the crew, and nearby Soldiers must be considered for both positions.

Figure 2. A typical storyboard used for new material development.

Figure 2 provides an example of a typical storyboard page used for developing original materials as opposed to altering existing media. These pages were appropriately labeled to differentiate new materials from reused materials to alert the programmers.

Storyboard formats can be adapted to facilitate the reuse of existing materials into new, revised, point of need lessons. Our reuse of existing materials fell into two categories:

- Reuse of a single page, and
- Reuse of multiple pages or a sections (i.e., a piece of training covering a single topic).

Inclusion of existing materials frequently required minor changes such as image replacement, modification of navigation menus or action controls and buttons, modification of on-screen text, or modification of narrations. Figures 3 and 4 provide graphic, annotated examples of the storyboard adaptations we used to develop our IMI exemplars.

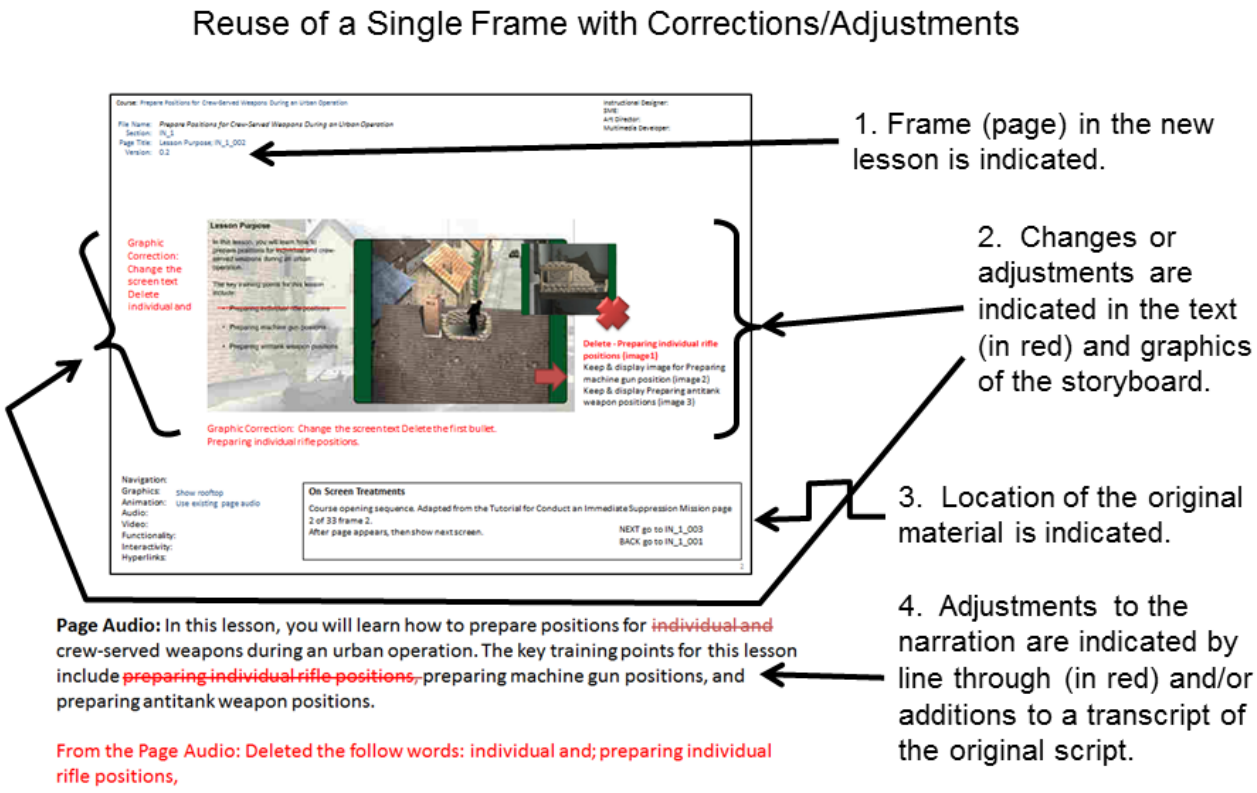


Figure 3. A storyboard example: reuse of a single frame of existing IMI.

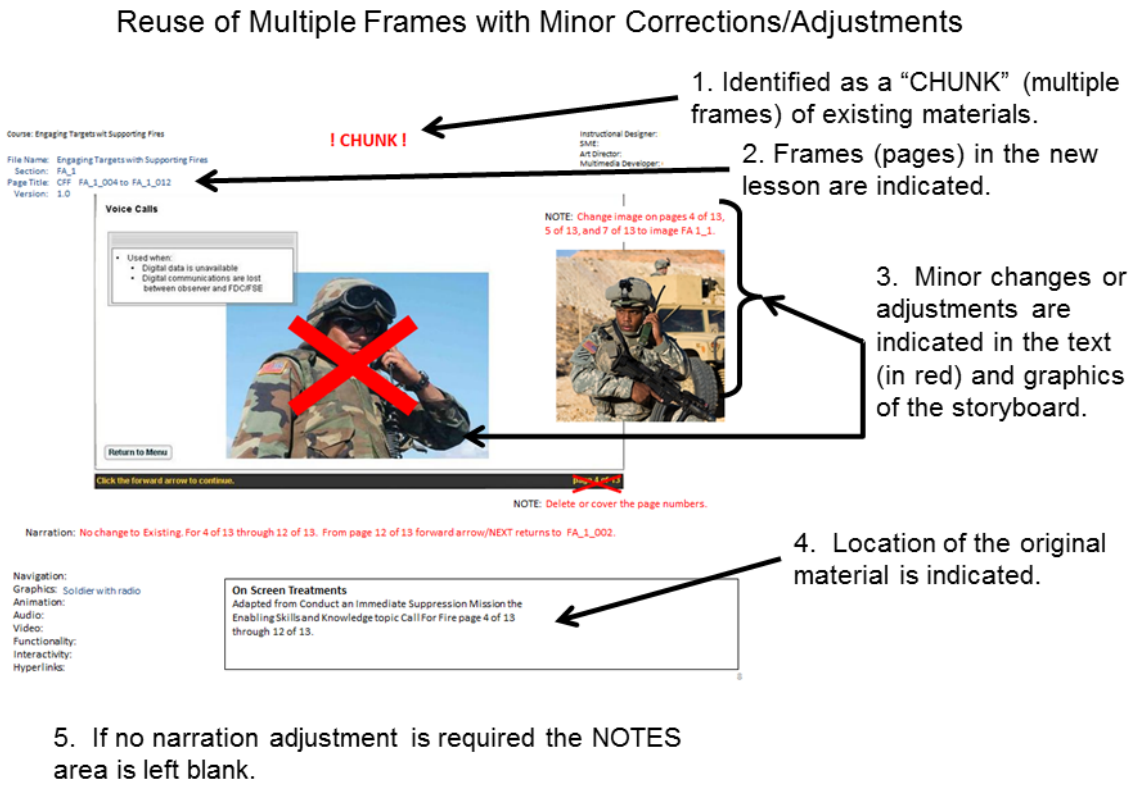


Figure 4. A storyboard example: reuse of multiple frames of existing IMI.

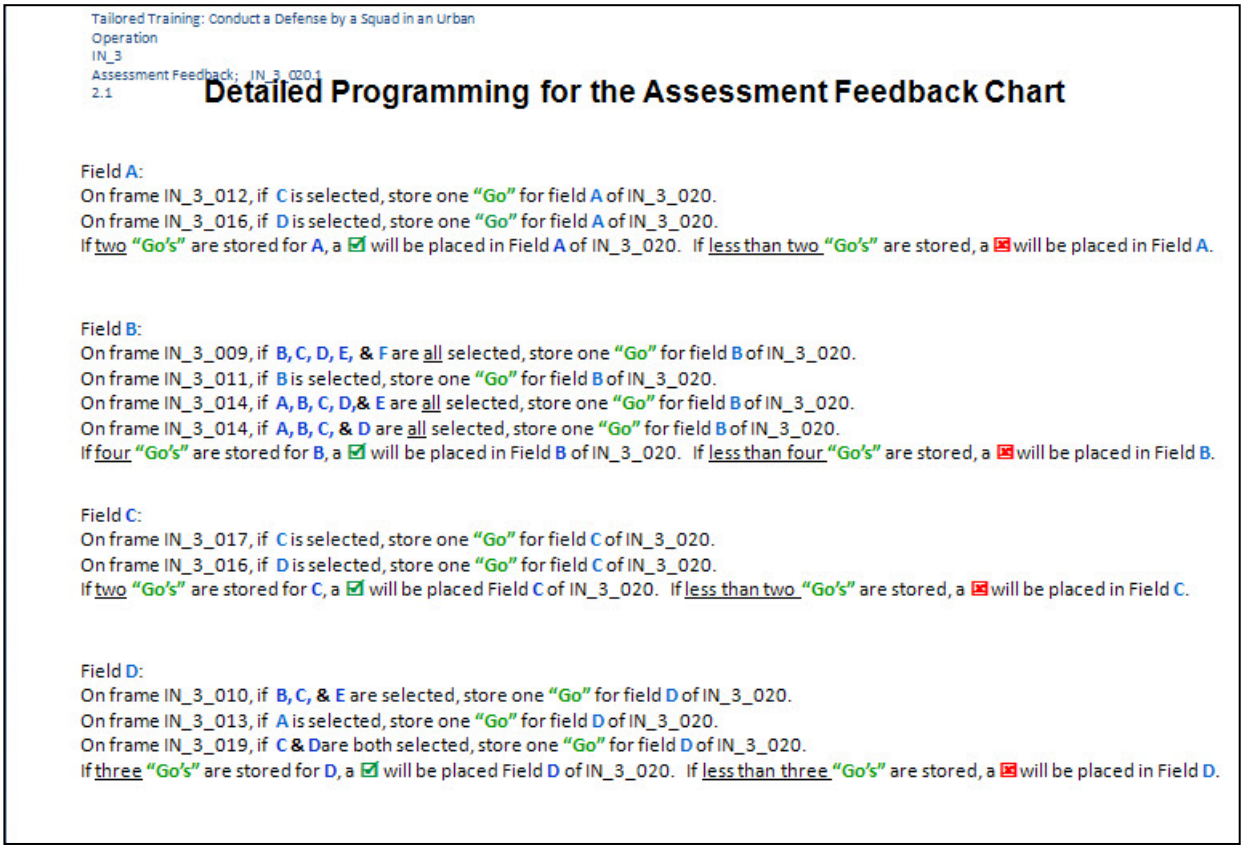
Care was exercised to minimize extensive changes in the material reuse. Experience showed that although storyboards were a convenient way to describe modifications, programmers at times had difficulty if the revisions were extensive. For extensive changes, it was quicker and more effective to assemble the modified pieces as new materials, simplifying the storyboard for the programmer.

Our pedagogy incorporated features described in research by Clark and Mayer (2008), Merrill's (2002) first principles of instruction, as well as criteria we developed in the first phase of this research (see Blankenbeckler, Graves, & Wampler, 2013; also Appendix A). We developed storyboards to provide complementary visual media, on-screen text, narration, and sound effects. Narrations were limited to 18 seconds or less, with rare exceptions lasting up to 30 seconds. We limited narrations to help learners maintain attention on the IMI. On-screen text was limited to no more than one-third (1/3) of the display area, with a true font size appearing as 12 point or larger on the screen. Images and diagrams were designed to be clear to Soldiers with normal vision, but more importantly they had to support the teaching point. All images were selected for a specific purpose. Photos were selected to depict a Soldier or Soldiers engaged in actions related to the teaching point, or a scene that clearly depicted the teaching point. Graphics used standard, common military map symbols or graphics. Obscure or less common selections were given a legend or explanation. Diagrams and supporting graphics were fabricated to support the teaching point. When needed (i.e., photographs could not be located or a specific

Soldier posture or example was required), VBS2 was used to build the scene. VBS2 also was used to create video segments as examples or models of an action or teaching point.

To address our concern as to how to present the adjust fire task as it occurs in time, we used VBS2 to capture successive graphics of the effects of rounds exploding at predefined locations, as well as the depiction of targets in realistic situations. While each individual storyboard received significant attention, they were designed to contribute to a section of content, often referred to as a "chunk." Chunking is a technique that groups items of content in terms of their relatedness within a task or knowledge domain (Sweller, 1988). A content chunking approach provides flexibility, complexity, and depth to the information presented. Chunking in this way contributed to the logical flow of our material, presenting it in a cohesive manner. The graphics and video, narrations, and text were integrated into training pages or frames. These pieces were programmed in Hyper Text Markup Language (HTML) creating web pages that could be accessed through standard web browser.

A further concern arose when developing the diagnostic assessments used specifically for the tailored training IMI and the think-ahead, check-on-learning assessments used in each of the point of need IMI variations. The IMI needed to be capable of providing learners with meaningful feedback in order for it to be effective. The pre- and post-assessments used for the tailored training IMI exemplars required greater specificity than the think-ahead and check-on-learning assessments. The pre- and post-assessments were used to guide learners to select training paths based on their demonstrated proficiencies. Figure 5 presents an example of the programming instructions we used to structure the feedback for multiple response questions.


Tailored Training: Conduct a Defense by a Squad in an Urban Operation
IN_3
Assessment Feedback; IN_3_020.1
2.1

Detailed Programming for the Assessment Feedback Chart

Field A:
On frame IN_3_012, if C is selected, store one "Go" for field A of IN_3_020.
On frame IN_3_016, if D is selected, store one "Go" for field A of IN_3_020.
If two "Go's" are stored for A, a ☑ will be placed in Field A of IN_3_020. If less than two "Go's" are stored, a ☒ will be placed in Field A.

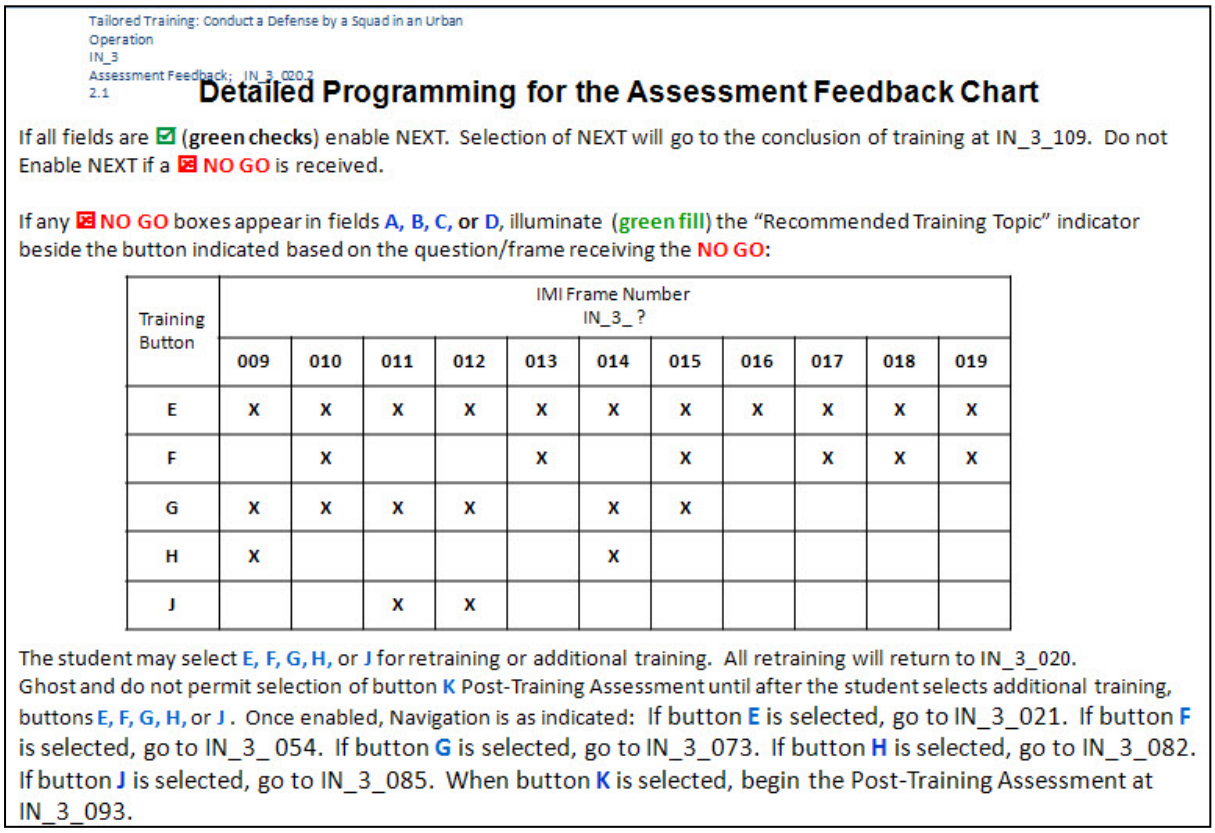
Field B:
On frame IN_3_009, if B, C, D, E, & F are all selected, store one "Go" for field B of IN_3_020.
On frame IN_3_011, if B is selected, store one "Go" for field B of IN_3_020.
On frame IN_3_014, if A, B, C, D,& E are all selected, store one "Go" for field B of IN_3_020.
On frame IN_3_014, if A, B, C, & D are all selected, store one "Go" for field B of IN_3_020.
If four "Go's" are stored for B, a ☑ will be placed in Field B of IN_3_020. If less than four "Go's" are stored, a ☒ will be placed in Field B.

Field C:
On frame IN_3_017, if C is selected, store one "Go" for field C of IN_3_020.
On frame IN_3_016, if D is selected, store one "Go" for field C of IN_3_020.
If two "Go's" are stored for C, a ☑ will be placed Field C of IN_3_020. If less than two "Go's" are stored, a ☒ will be placed in Field C.

Field D:
On frame IN_3_010, if B, C, & E are selected, store one "Go" for field D of IN_3_020.
On frame IN_3_013, if A is selected, store one "Go" for field D of IN_3_020.
On frame IN_3_019, if C & Dare both selected, store one "Go" for field D of IN_3_020.
If three "Go's" are stored for D, a ☑ will be placed Field D of IN_3_020. If less than three "Go's" are stored, a ☒ will be placed in Field D.

Figure 5. Example instructions to the programmer for providing feedback to learners.

Figure 6 presents an example of the programming instructions we used to guide learners in training after the pre-assessment.



Tailored Training: Conduct a Defense by a Squad in an Urban Operation
IN_3
Assessment Feedback; IN_3_020.2
2.1

Detailed Programming for the Assessment Feedback Chart

If all fields are ☑ (**green checks**) enable NEXT. Selection of NEXT will go to the conclusion of training at IN_3_109. Do not Enable NEXT if a ☒ NO GO is received.

If any ☒ NO GO boxes appear in fields **A, B, C, or D**, illuminate (**green fill**) the "Recommended Training Topic" indicator beside the button indicated based on the question/frame receiving the **NO GO**:

Training Button	IMI Frame Number IN_3_?										
	009	010	011	012	013	014	015	016	017	018	019
E	X	X	X	X	X	X	X	X	X	X	X
F		X			X		X		X	X	X
G	X	X	X	X		X	X				
H	X					X					
J			X	X							

The student may select **E, F, G, H,** or **J** for retraining or additional training. All retraining will return to IN_3_020. Ghost and do not permit selection of button **K** Post-Training Assessment until after the student selects additional training, buttons **E, F, G, H,** or **J**. Once enabled, Navigation is as indicated: If button **E** is selected, go to IN_3_021. If button **F** is selected, go to IN_3_ 054. If button **G** is selected, go to IN_3_073. If button **H** is selected, go to IN_3_082. If button **J** is selected, go to IN_3_085. When button **K** is selected, begin the Post-Training Assessment at IN_3_093.

Figure 6. Example instructions to the programmer to provide training guidance to the learner.

We used a multi-phased system to review and approve the storyboards. First, the developers constructed the storyboards, followed by an internal review. This initial review was to ensure accurate content and up-to-date doctrine, etc. Storyboards were then produced through an iterative process of development, review, and comment between military subject matter experts and the Government. Once all members of the research team were satisfied with the content and design, the edited storyboards were provided to graphic artists. These artists refined the graphics and text. Finally, the materials were provided to the programmers. After the programmers assembled the materials, a production review was used to assure desired navigation and functionality. The *Alpha* version of each IMI module was returned to the developer for review to assure correct translation of intent, compliance of the graphics with desired appearance, and navigation of or reaction to the software. Researchers then reviewed the *Alpha* version with the list of corrections and edits identified by the development team. These corrections and edits were provided to the artists and programmers. The corrected copy became the *Beta* version, which was returned to the developer for a similar review and comment by our research team. After the final reviews and corrections, the development was complete. This cyclic, iterative review was intended to assure a quality product for the learners.

The Structure of the IMI Modules

Adjust Indirect Fire. For two of the three Adjust Indirect Fire modules, the instructional information and activities were arranged in sequence, following the order of steps in the Adjust Indirect Fire task (see U.S. Army, 2008). Each step in this procedure depends on the previous steps. For example, doctrine stipulates that the standard indirect fire mission takes place in three transmissions. Once the initial adjusting round impacts, the data for adjustments are transmitted. These adjustments close in on the target's location before the final call to 'fire-for-effect.' Doctrine also stipulates the transmission to end the mission. Standardization helps users to communicate effectively with an indirect fire unit's fire direction center (FDC) and to obtain the desired effects against a target.

The core IMI module for Adjust Indirect Fire differed from the familiarization and tailored training IMI modules only in that it focused on the immediate suppression mission, a common mission that is initiated with an abbreviated call for fire. The immediate suppression mission is an emergency fire mission designed to quickly obtain suppressive fires on a threatening target. Only essential information is needed for a single transmission to the FDC. Training materials were focused only on how to transmit an immediate suppression mission; they were not compared with the standard call for fire. The standard procedure for transmitting adjustment data was included, as was the specific information to conclude the mission. The reasons for providing a target description were reviewed, although it is not a required element of the mission. Materials were structured in chunks, following the sequence of immediate suppression mission.

Conduct a Defense by a Squad. The three modules for the Conduct a Defense by a Squad were a greater challenge than the Adjust Indirect Fire modules. When conducting a squad defense, a leader is engaged in complex cognitive tasks when planning and executing an urban defense, positioning subordinate elements and supporting weapons (U.S. Army, 2008). The leader has to track multiple variables, make sound judgments about many issues, and supervise subordinates' concurrent individual and collective tasks. Further, a leader must adhere to standard procedures, although the order of steps and measures of procedures are not fixed. In this task, some steps may be omitted and others modified to save time. Altering some steps often has no detrimental effect on this mission. Given the time pressures in conducting a defense, work has to be prioritized to enable it to be successfully executed. For example, positions and fields of fire for machine guns and anti-tank weapons must be examined, proofed, and adjusted quickly to prevent wasted time, effort, and to allow time for improvements.

All three of these IMI modules address primary, alternate, and supplementary positions. The familiarization IMI module employed training materials structured in chunks to address each of these positions. Some sections address how to place units or weapons in optimum locations and control fires. Other sections address how to prepare positions. The tailored training IMI module used assessments that asked the learner to evaluate the decisions and weapon positions of a hypothetical peer. The blocks of training were designed to address how to prepare positions, place units or weapons in optimum locations, and control fires.

The core IMI module introduced general characteristics of the Javelin Close Combat Missile (CCM) system. Initial instruction focused on the Javelin's capabilities and limitations for firepower, maneuver, and protection. Subsequent instruction focused on how to employ the Javelin CCM. Employment considerations are presented in the context of a tactical scenario providing contrasts of more, or less, viable tactical judgments. Principles of Fire Control serve as the context concerning position selection and controlling fires. Training content was organized within the module to guide new learners to correct weapon preparations and placement.

Developing Diagnostic Assessments for Tailored Training IMI. A key feature of the two tailored training IMI modules was feedback from the pre- and post-training assessments. In the Adjust Indirect Fire module, the learner was provided performance feedback on each task step. Figure 7 shows a sample feedback display for the Adjust Indirect Fire task.

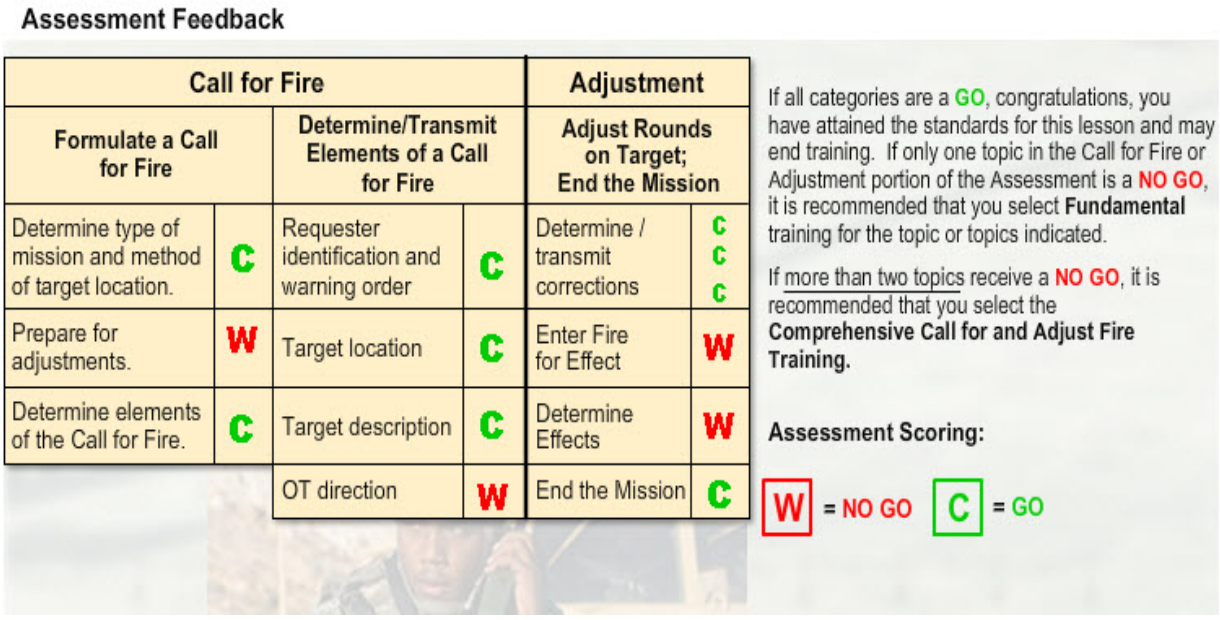


Figure 7. Feedback format for both the Pre- and Post-Training Assessments for the Adjust Indirect Fire tailored training.

The pre- and post-assessments recommended to Soldiers ways in which they could address identified shortcomings in their understanding. Learners were given training recommendations related to the primary navigation menu for the module. This menu is shown in Figure 8.

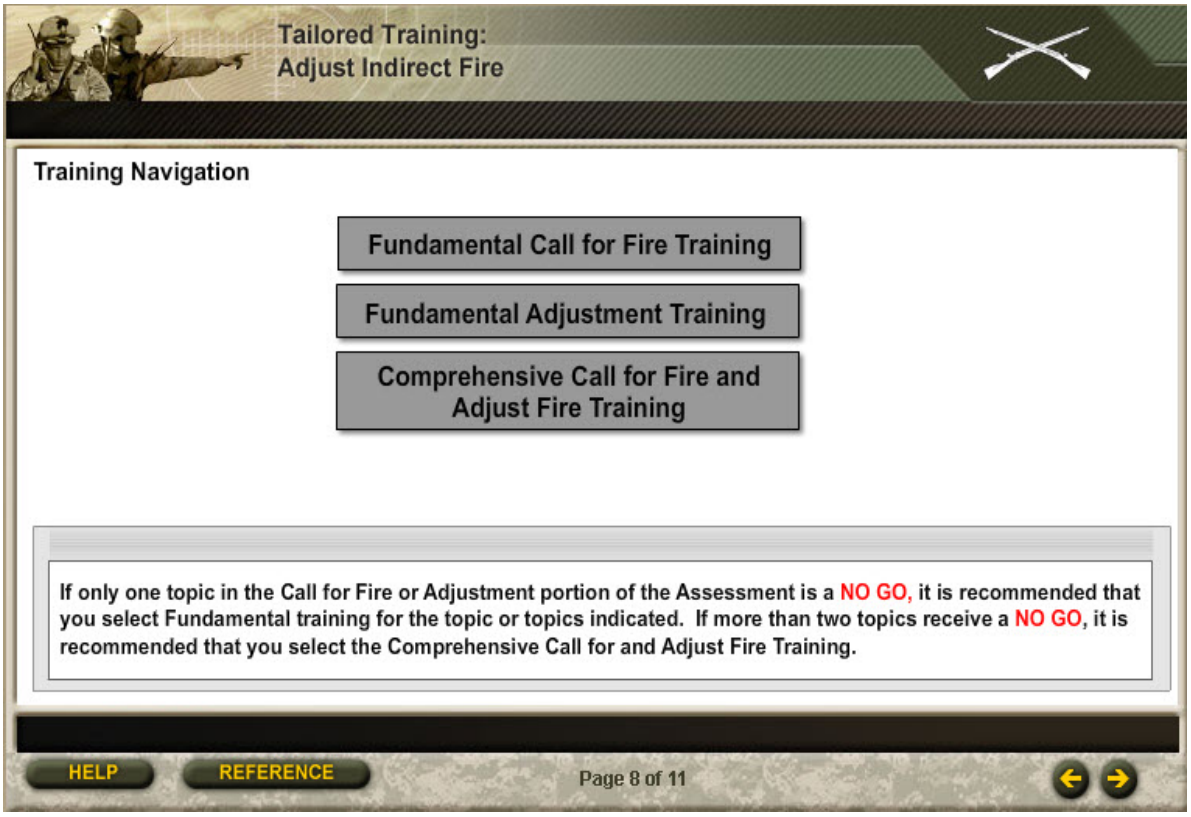


Figure 8. Primary Training Navigation Menu.
Note: the guidance from the Assessment Feedback page is repeated.

For the Conduct a Defense by a Squad, the assessments were designed differently. The feedback was focused on the three principle subject areas addressed by the modified task. Based on how learners performed on the assessment, recommendations were made concerning the various training options. These recommendations were shown in the lower right corner of the assessment feedback screen (see Figure 9).

Like the tailored Adjust Indirect Fire module, the elements of the feedback related directly to the primary training navigation menu for the module. While feedback was only provided for three principle subject areas, the training recommendations were based on the assessment questions that were incorrect. Some questions overlapped subject areas and resulted in multiple training recommendations.

Assessment questions for the Adjust Indirect Fire module were answered and scored as single responses. However, the Conduct a Defense by a Squad assessment questions contained both single and multiple response questions. A sample of one of the multiple response questions is provided in Figure 10.

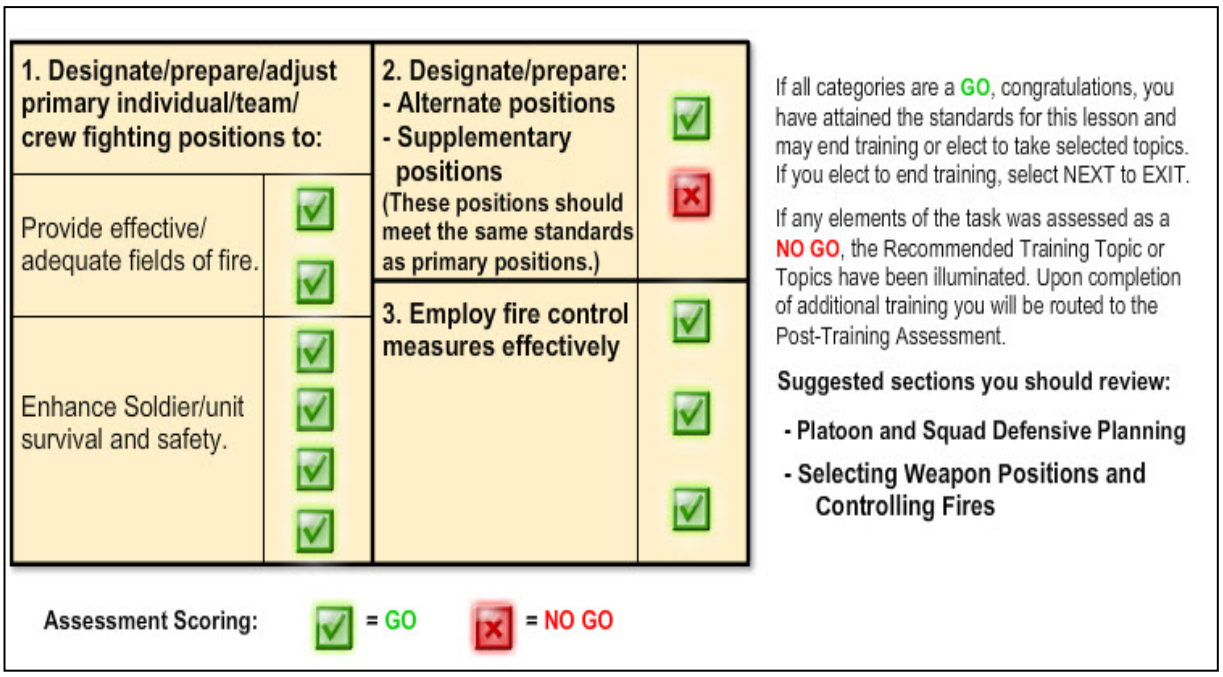


Figure 9. Feedback format for both the Pre- and Post-Training Assessments for the Conduct a Defense by a Squad tailored training.

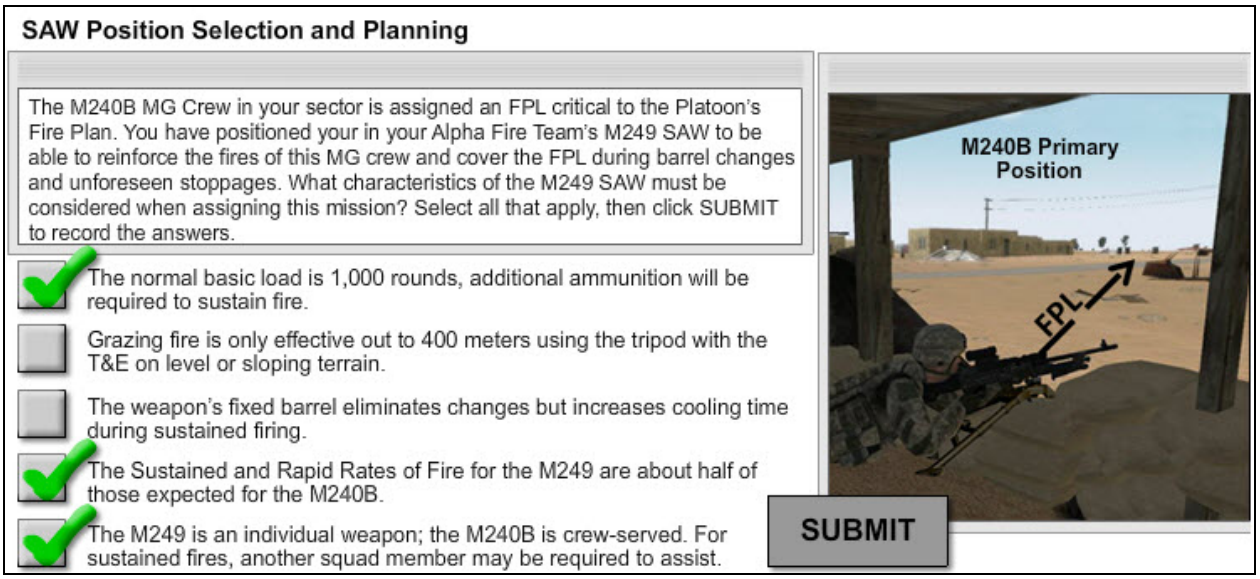


Figure 10. A sample multiple response question from the Post Training Assessment for the Conduct a Defense by a Squad tailored training.

The diagnostic assessments for Adjust Indirect Fire used a tactical scenario, which required fire engagement and adjustments on an enemy target. We used screen shots from the VBS2 software to reflect imagery required during specific sequences. VBS2 enabled us to present realistic target images, the effects of the artillery rounds, and the placement of targets and

effects to replicate what is required for the Adjust Indirect Fire task. The same sequence of task steps and real-world problem solving was used within the training modules. VBS2 was useful in creating realistic still images of the battlefield, including high quality impact effects.

Our diagnostic assessments for the Conduct a Defense by a Squad also used a scenario based format. Two basic scenarios were used where the Soldier played the role of: (a) a squad leader replacing the leader who had established the defensive positions, or (b) a leader correcting and refining the positions that a subordinate had established. In both situations, the learner was provided diagrams of the broader defense and unit positions to provide context for the scenarios. Within training modules, we used shortened scenarios to cover a larger number of concepts and principles. All assessments and sections of training were based on real-world tactical problems and applications of principles in combat. The training encouraged learners to exercise tactical judgment, supporting their development into their future role as squad or fire team leaders.

Incorporating Additional Resources. To make the IMI useful to learners who would like to pursue their learning in greater depth, we provided access to additional training materials. In each of the modules, additional resources were made available through a "References" tab. The references included all available doctrinal publications related to the tasks being trained. In addition, the relevant sections of the documents were provided for quick reference.

An example of the references for the Adjust Indirect Fire training is provided in Figure 11. The references for Conduct a Defense by a Squad lessons were more extensive, given the variety of tasks associated with conducting a defense. The references are available from all pages in all modules for learners who desire additional details.

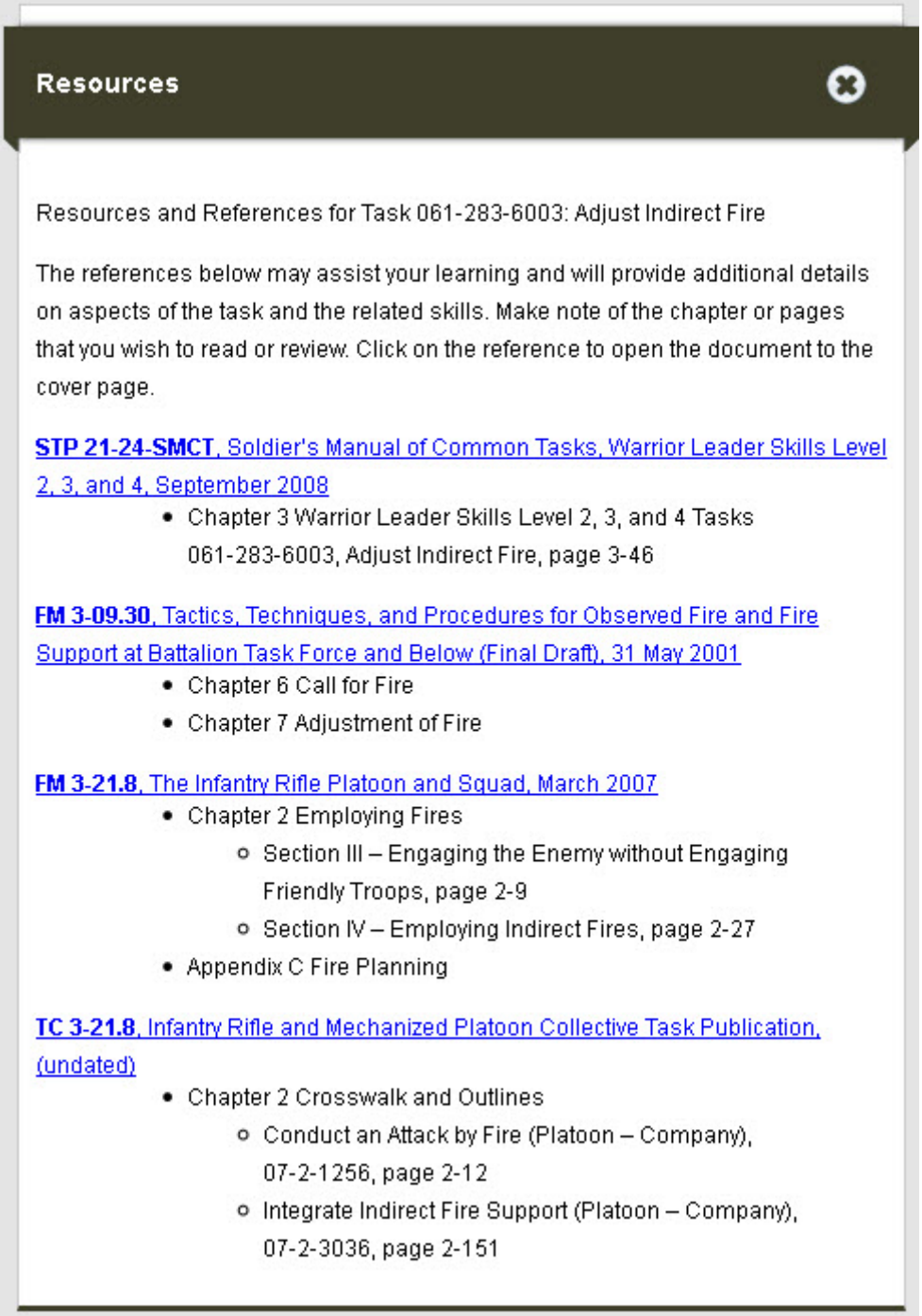


Figure 11. Adjust Indirect Fire References provided in the IMI modules.

Pulling the Pieces Together

One of the major hurdles we encountered in this research concerned how to reuse existing Army IMI. Given the variety of IMI available and the different ways in which it can be developed, deployed, and archived, we had to use a variety of software tools and programming languages. A variety of tools were used to extract, develop, correct, and program materials for this effort (see Table 4).

Table 4
Software Tools and Programming Languages Used to Build the IMI Modules

Tool	Examples
Software	Adobe Flash (ActionScript 2 & 3) Adobe Dreamweaver (HTML & JavaScript & CSS) Adobe Photoshop (graphics) Adobe Captivate Camtasia Studio (screen capture software) Snag-it
Programming Languages	ActionScript 2 & 3 HTML JavaScript CSS

Note: HTML refers to Hypertext Markup Language; CSS refers to Cascading Style Sheets.

We had to develop some workaround solutions to problems we encountered when trying to reuse parts of an existing IMI. As indicated in our initial report (see Blankenbeckler, Graves, & Wampler, 2013), there was no centralized database or learning content management system (LCMS) from which we could draw IMI materials for reuse. For almost every case, we had to trace IMI to the proponent that had developed and retained the original source files.

In some cases, the source files were incomplete and not viable for reuse. A few of the existing lessons had all source materials, including the storyboards and complete instructional media design packages (IMDPs) (TRADOC, 2003). Those with complete IMDPs were at times inaccurate in their verbal descriptions of design and instructional strategies. While some did provide complete descriptions of the training program, lesson development support information, and wire-frame diagrams that identified the Terminal Learning Objectives (TLOs), Enabling Learning Objectives (ELOs), and SCOs that could support reuse decisions, a detailed and careful review of the materials in the programmed IMI was required.

Having a consistent pedagogy was a critical factor in our reuse decisions. The graphic, narration, or segment we were considering had to fit our purpose and approach. In a few cases, we were able to modify the instructional approach to accommodate the materials to be reused. Review of the existing IMI was also required to assure that equipment, uniforms, doctrinal terms, as well as tactics, techniques, and procedures (TTP) portrayed were current and not distracting to the learner.

Once training tasks were selected, a more detailed review of the related IMI was undertaken to identify the precise elements desired for reuse. This process resulted in mapping the existing IMI to identify the desired elements. This mapping, while time consuming, proved most valuable to the graphic artist and programmers who extracted or captured the desired materials. The target element could be an entire module or sub-element of an existing lesson, a short animation, a demonstration, a single image, a check-on-learning, or an assessment.

The FCoE's materials—specifically for Adjust Indirect Fire—were the easiest to work with to extract sections and to adapt to the pedagogy we used for all three of the point of need lessons. The source files contained much of the desired material. To a great extent, existing animations, on screen text, transition effects, and narrations were reusable or were easy to edit. Some minor alterations were required:

- We had to replace some graphics because they mixed woodland battle dress uniform (BDU) and desert BDU, which preceded the current Army Combat Uniform (ACU). Mixed uniforms were often observed in the early years of our conflicts in Iraq and Afghanistan. These were replaced with Soldiers in ACU (see Figure 12).

Figure 12. An example of image substitution in reused IMI. The new image provided an action photo of a battle-ready Soldier in the current ACU to replace the existing, more passive image of a Soldier in the outdated BDU.

- Some minor issues needed to be corrected concerning target location and grid coordinate information displayed in on-screen text boxes or vocalized in the narration. The on-screen text boxes were replaced or edited. New narrations were dubbed-in to reflect current doctrine (see Figure 13).

Figure 13. An example of edits to on–screen text in reused IMI.
Note: The correction reflected current doctrine, omitting the word "grid" and providing the 100,000 meter grid square identification as part of the target location to be transmitted.

- We framed some animations to place on-screen navigation buttons. These adjustments assured that existing graphics and text pertinent to training were displayed properly.

- We edited some narrations to account for the revised timing of animations.

That said, much of the FCoE's existing material was reusable with only minor adjustments for the familiarization IMI module. To a lesser extent, this remained true in the core IMI module that was developed. The pre- and post-tests and comprehensive Adjust Indirect Fire training developed for the tailored training IMI module were designed without reuse of existing materials. However, optional training blocks in the tailored training IMI module used content from the familiarization and core IMI training modules.

IMI concerning infantry leader skills and common tasks were provided by the Iowa National Guard Distributed Learning Development Center. These were the oldest of the source materials we collected. Due to the age of the materials, some were unusable because the source code had been superseded by newer versions of software and were no longer compatible. In these cases, we were able to capture video and audio recordings of the IMI running on Army Knowledge Online (AKO) My Training Tab (MT2) site. Using multi-track recording, we were able to capture video and audio on separate tracks to enable us to later edit each track independently.

The only notable difference in the way the captured media performed was that the video segments had to play completely before navigation buttons became active. Learners who desired to speed through the materials encountered some delays while waiting for segments to finish playing. In addition, getting the video and audio to synchronize was initially an issue, but this was easily resolved with audio editing programs. Some existing material was reusable with only minor adjustments, such as changing the placement of machine guns and anti-tank systems used in one of the familiarization IMI modules.

In summary, the team was able to reuse and integrate images, animation and video segments, menus, and narrations in five of the modules. However, in the core Conduct a Defense by a Squad IMI module (Designate and Prepare Urban Fighting Positions for a Javelin Team), editing proved far too complex and time consuming. The resulting animations and narrations were choppy and did not seem to match well with the selected methods of instruction. A very limited number of images were extracted and reused in this module. Recall that about 30% of the final point of need IMI modules were created from existing IMI, while 70% had to be developed as new material.

We did not use a LMS to run the IMI exemplars, although they could be incorporated into such a system. Instead, Hypertext Markup Language (HTML) was used, enabling the IMI exemplars to run in a web browser. While this approach precluded some data collection techniques and required additional programming for the pre- and post-assessments in the tailored training IMI exemplars, its "low tech" design maximized compatibility across systems. Using HTML also minimized the unintended effects of code that remained from the previous IMI or LMS. These left-behind elements tended to negatively affect timing or presentation of content.

Left-behind elements often introduced problems with navigation. These problems were overcome by establishing additional navigation selections within the instructions frame. The supplemental navigation buttons were made a standard across all six exemplars. While generally intuitive, some learners initially were frustrated by this multi-level navigation scheme. Supplemental buttons were only present when needed and the next (forward) arrows flashed when the narration, animation, or on-screen actions were completed to provide a visual cue. During the assessments, some learners did experience navigation issues, occasionally ending up where they had not intended to be. With minor assistance, all learners were able to use the navigation effectively.

Instructional Design and Point of Need

Early in this research, we focused on instructional design issues over those of technology—although both issues are important in the point of need context. One major factor in instructional design is determining an audience's learning needs and then developing instruction to meet those needs (Clark & Mayer, 2008). Another focuses on issues surrounding how to maintain quality of instruction when implementing it with particular technologies.

Problems can arise when technology is emphasized over the selection and presentation of training content (Clark & Mayer, 2008). A piece of training can be well-designed for one

technology, but poorly-designed for another. Not all features of instructional design are transferable across technologies. For example, the fonts, font sizes, graphics, audio, and video media used in a design are in part determined by the specifications of the intended technology, i.e., screen size, processing power, or availability of bandwidth to support applications. A piece of IMI designed to be viewed on a computer screen is not optimally viewed on a smartphone.

Rather than focus solely on how to apply new technology in educational and training settings, Mayer's research (see Mayer, 2003; Clark & Mayer, 2008; Mayer, 2009) has sought to identify general principles for good multimedia instructional design. Accordingly, concerns with instructional design must always take precedence over how to incorporate new educational technologies. For instance, the design features of IMI that are optimal for learning are rarely those that require a lot of bandwidth. In fact, when a training developer overemphasizes technology, the actual content and desired learning outcomes may be lost to all the "bells and whistles."

The critical features of effective instructional design reduce irrelevant information and help learners think more deeply about the training domain. According to Clark and Mayer (2008), these critical design features address three goals: (a) reducing extrinsic cognitive processing, (b) managing intrinsic cognitive processing, and (c) facilitating generative processing. Table 5 summarizes the features of well-designed IMI identified by Mayer and colleagues (see Veronikas & Shaughnessy, 2005; Mayer, 2009; Moreno & Mayer, 2007; Clark & Mayer, 2008).

Table 5
Features of Well-Designed IMI from Mayer and Colleagues

Goal	Features	Description
To Reduce Extrinsic Cognitive Processing	Coherence	Eliminating extraneous words, pictures, images
	Signaling	Highlighting important words (e.g., section headings, highlighting, boldface font)
	Redundancy	Combining animations with narrations rather than animation, narration and text
	Spatial Contiguity	Placing corresponding portions of pictures and words near each other
	Temporal Contiguity	Presenting corresponding animation and narration simultaneously rather than successively
To Manage Intrinsic Cognitive Processing	Segmenting	Presenting narrated animation in learner-paced segments
	Pre-training	Providing pre-training in vocabulary and key concepts (e.g., outlines, key learning objectives, bottom line up front)
	Modality	Combining animation (visual) with narration (auditory), not animation (visual) with text (visual)

Table 5 (Continued)
Features of Well-Designed IMI from Mayer and Colleagues

Goal	Features	Description
	Guided Activity	Prompting learners to select, organize, and integrate new information
	Reflection	Encouraging self-reflection to activate organization and integration of new information
	Feedback	Providing learners with proper schemas to repair misconceptions
	Worked Examples	Leveraging worked examples to show how to work though tasks/problems step-by-step
To Encourage Generative Processing	Personalization	Communicating in an informal/conversational style
	Voice	Narrating in a non-accented voice rather than a machine-simulated voice
	Pacing	Allowing learners to control their pace, and process smaller chunks of information in working memory
	Sequencing	Ordering information to move from old (familiar) information to new (unfamiliar) information
	Clear Structure	Using a familiar structure/pattern for presenting information (e.g., compare-contrast, classification, enumeration, cause-effect)

Table 5 also describes design features which are focused on three different goals to influence cognitive processing. The first group of features, which are focused on extrinsic cognitive processing, seek to reduce distractions and make critical information stand out to learners. Applying these features likely helps learners better identify and learn relevant content. These techniques are focused on selecting the right words and images, making sure critical ideas stand out, not overloading the learner, and following a logical use of visual space and training time in the design. We applied these techniques by limiting the amount of text on slides, selecting images to support the key learning points, and limiting each span of narration to approximately 20 seconds to not overload learners and help maintain their attention (see Clark & Mayer, 2008).

The second set of features, concerning intrinsic cognitive processing, focus on helping the learner to make sense of the information they are learning. This goal focuses on related principles that allow learners to pace their learning, make use of preexisting knowledge, and reduce attention conflicts within single sensory modalities (e.g., presenting static text with animation). We applied these techniques by providing a branching navigation system within the IMI, providing checks on learning, and for the tailored training IMI, pre- and post-diagnostic assessments.

The last set of features concern generative processing and are intended to support learners in achieving a deeper understanding of the material they are learning. In terms of these features, the goal is to reduce as much as possible the barriers to understanding by establishing an appropriate communication style with a learner (Clark & Mayer, 2008). In order to accomplish this, we used terminology familiar to our intended military learners in order to introduce new concepts and made connections between old (familiar) and new (unfamiliar) information.

In our initial review of existing Army IMI, we found both positive and negative examples of design features to consider (see Blankenbeckler, Graves, & Wampler, 2013). For example, a single path, "three to five frames and a check on learning quiz" approach was taken in some lessons we reviewed. This seemed to be a cost-efficient, but less effective approach for our needs. While it was perhaps suitable for a general training audience or to introduce the task to an inexperienced population, it has a very low level of interactivity. Simply reviewing selected sections of a field manual might provide an equally effective learning experience.

Likewise, we reviewed some examples of high-end multimedia IMI, which relied on extensive video with staged action scenes and a decision-action-consequence structure. While it seemed effective and engaging, this design approach is very costly and time consuming to produce. Moreover, this type of IMI would require a very high bandwidth connection to be deployed online. While certainly engaging and often entertaining, these products would not lend themselves to adaptation or quick review.

Our designs and content ultimately incorporated the same standards we used to select materials for reuse, by reverse engineering the criteria that was being used to evaluate existing IMI for reuse. Table 6 provides a summary of these considerations, which emerged during the previous phase of this effort, as detailed in Blankenbeckler, Graves, and Wampler (2013).

Table 6
Point of Need Design Criteria: Reverse Engineering of the Criteria for Evaluating Existing IMI

Criterion	Point of Need Design Considerations
Complexity/Depth of Information Presented	Provide sufficient content for the desired coverage of the task/subject, but enable down-select to focus on a specific learning need.
Viable Examples	Provide contextually relevant examples. Use multiple or varied examples that permit Soldiers to generalize principles by deriving consistent patterns across examples. Worked examples of correct procedures would be used, as well as the detection of the errors of others. Apply tailoring principles: backward fading, withdrawal of scaffolding, etc. when appropriate.
Narrative Flow	Provide a coherent, logical narrative. Assure that pages/frames that follow build on preceding frames. Integrate tactical examples or situations when possible.
Presentation is Focused vs. Diffused	Maintain a clear topical focus and do not permit training to meander.

Table 6 (Continued)
Point of Need Design Criteria: Reverse Engineering of the Criteria for Evaluating Existing IMI

Criterion	Point of Need Design Considerations
Outcome Meets Goal	Focus training to meet the goal. Address the specific point of need and target audience.
Grouping of Content	Group information and blocks in a logical coherent structure.
Timing	Present the material in a manner that permits the learner to understand a learning point before advancing to the next. However, structure should facilitate the learner jumping around in the media to quickly review relevant points, if needed.

In addition to the criteria summarized in Table 6, we recognized the targeted nature of point of need training. Each module would need to be custom-made, designed to: (a) fit the unique characteristics of the task, (b) cover the topic to the desired level of familiarization, core, or tailored training IMIs, and (c) engage the targeted training audience. Moreover, each of the criteria we derived in our initial review mapped onto the IMI design goals described in Mayer and his colleagues' work (i.e., Clark & Mayer, 2008; review Table 5). For instance, timing and grouping of content relate to the goal of reducing extraneous processing. Providing viable examples, focusing the presentation, and carefully attending to the complexity of the information presented relate to managing intrinsic cognitive processing. Some criteria, such as narrative flow, cross-cut many of Mayer's goals to include the goal of encouraging generative processing. A table including all criteria we used is included in Appendix A.

While these features are important for designing effective IMI, training developers and educators should also consider how the different design features combine to best fit different learners. Different learners may benefit most from different types of instructional designs, with more advanced learners potentially benefitting more from less structured designs than learners who are new to a knowledge domain (Dyer, Singh, & Clark, 2005). In other words, given that learners have different background knowledge and learning needs, IMI can be designed to specifically address those needs in terms of its content, features, and design.

Conclusion

This research report is the second in a series of three related to our research on incorporating the ALM point of need concept into Army IMI. The first report presented the results of a survey of existing Army IMI focused on Combat Arms (see Blankenbeckler, Graves, & Wampler, 2013). This report presents our process and rationale in developing six IMI exemplars focused on three types of learning needs: familiarization, core, and tailored training.[7] The third report will present the findings of an experimental test of the point of need IMI we conducted with NCOs enrolled in the Warrior Leader Course.

[7] Please contact Dr. Rhett Graves at the U.S. Army Research Institute for copies of the IMI exemplars: thomas.r.graves5.civ@mail.mil.

Our main focus in this report was on instructional design. Instructional design can reflect the ways in which information is transformed, packaged, and then communicated for an audience of learners (see Swanson et al., 2013). The question for point of need training is how to best transform, package, and communicate information to address the needs of a specific audience. The selected technology to deliver training is an important part of the equation, but it is a different type of question than that asked about instructional design. The answer to instructional design questions are related to the cognitive, rather than the geographic accessibility of information—i.e., the training materials are appropriately complex to be engaging, understandable, and effective (Harun, 2002; Walsh, 2010).

Effective instructional design also addresses the recognized learning needs of an audience. The audience often shares common characteristics in terms of its level of knowledge and experience. Shared understandings and experiences may influence the way the respective groups learn. For instance, Dyer, Singh, and Clark (2005) found that highly structured training was beneficial for Soldiers in One Station Unit Training (OSUT), whereas Soldiers enrolled in the Infantry Officer Basic Course (IOBC) benefitted from a less structured training environment. For OSUT Soldiers, training materials controlled what and how information was being presented; for IOBC Soldiers, learners were allowed to self-select how they were accessing information. Further, these two groups of Soldiers were different in average age and civilian education level. Yet, each group appeared to benefit more from a training design that fit their respective level of knowledge and experience. In addition to understanding what makes a group of learners unique, it is also important to understand the impact that differences among individuals can have on learning. Any IMI that can address the challenge presented by ALM's point of need concept requires an instructional design to address defined learning needs of a particular audience and individual learners (see Pashler, McDaniel, Rohrer, & Bjork, 2009).

This research report focused on the process and rationale in developing six IMI exemplars designed to address the ALM's point of need concept. Point of need is intended to both address the geographic accessibility of information by way of technology, and the cognitive accessibility of information by way of instructional design (Blankenbeckler, Graves, & Wampler, 2013).

To develop the IMI exemplars, we reviewed existing Army IMI for potential reuse in developing new point of need IMI focusing on three types of Soldiers' learning needs: familiarization, core, and tailored training. Most existing materials were designed using a different pedagogic approach, addressing a wide audience, rather than addressing more narrowly defined learning needs. Approximately 30% of the material used in our exemplars is reused; the remainder needed to be developed anew.

We used a process to develop the IMI that involved multi-phased drafting, evaluation, development, and re-evaluation activities. Storyboards were developed and reviewed by the research team. Once storyboards were evaluated, corrected, and revised, they were passed to the graphic design and programming team. Then, the graphic design and programming team produced an *Alpha* version of the IMI module for review. The research team reviewed and made

corrections to the *Alpha* version; the corrections were sent to the graphic design and programming team for development into the *Beta* version of IMI.

To design IMI to address point of need, designers and developers should focus first on instructional design issues to meet an identified learning need, then on incorporating novel technologies. We identified and applied a number of instructional design techniques to reduce extrinsic processing, manage intrinsic processing, and increase generative processing (see Table 5; also Moreno & Mayer, 2007). Many of these techniques were supported by our review of existing Army IMI, which enabled us to identify positive and negative features of different instructional designs for ALM learner-centric context.

Large-scale reuse of existing materials to develop point of need IMI had a low payoff. The availability of materials, time required to integrate located materials, and technical complexities of completing the integration made designing new IMI a more efficient and far more effective option. Transforming materials made for the "one size fits all" training approach into point of need training proved a difficult challenge. While existing IMI did provide images and a few animation segments of value to our targeted point of need, little of the existing IMI was reusable. The search for those reusable fragments, modifying or correcting them to user acceptability or doctrinal correctness, and integrating them into the instructional design proved more time consuming than creating them anew. While LCMSs could potentially simplify this process in the future, the larger the anticipated data base, the more disciplined, regimented, and restricted it would need to be. The availability of related materials is not a direct indication that they can be integrated into an instructional design that meets the needs of the target training audience.

Communicating design intent and reuse parameters to programmers can be done with effective storyboards. Even in the absence of source materials, technically savvy software technicians were able to frame workarounds that captured and integrated the desired materials. However, care must be exercised. The storyboard cannot become so filled with corrections and changes that the intent, teaching point, or desired activity or interactivity becomes confusing. Instructional intent must be clear to avoid delaying the production process or causing extensive edits and changes to materials.

The two factors that proved most critical to our effort were (1) defining the needs of the target population, and (2) selecting an instructional design approach that addresses the needs of that population. One of the primary reasons that most IMI is unsuitable for reuse is that it is initially designed to address a broad audience and not focused on a point of need audience. Well-designed point of need training should not only address what to do, but why and when to use the knowledge and skills trained. Successful determination of the needs of the target audience and tailoring the materials to specifically address those needs in terms of design, content, and features provides the most effective learning experience for an audience.

Recommendations

In summary, we offer the following recommendations to any instructional designers interested in adapting existing IMI, or creating new IMI, focused on specific audiences' learning needs:

- Specify the needs of learners in terms of their point in career, prior knowledge, and experience in order to select appropriate content.
- Maintain focus on the type of technology you are designing the instruction for, i.e., porting IMI designed for a computer screen to a hand-held device will likely cause problems with readability, etc.
- Remember that low-tech and well-designed IMI is more effective than poorly designed IMI with lots of "bells and whistles".
- Design instruction to reflect a coherent pedagogy, i.e., design problem-based instruction around actual problems from the field.
- If existing IMI is to be reused, ensure that all source files are available and can be edited in current versions of software. As a workaround, sections of existing IMI can be recorded while playing within the host LMS. The new audio and video files can be edited to fit the new instructional design objective, avoiding the unintended problems that arise when making modifications at the level of source code. The older the source files are, the more problems that may arise. The Army needs a centralized repository for all IMI source files. This would be a tremendous asset to future efforts to tailor IMI to Soldiers' point of need and is needed if units across the Army plan to exploit existing IMI.

In terms of specific design features to incorporate into needs-focused IMI, we recommend the following:

- Whenever possible, frame assessments and checks-on-learning around tactical scenarios in order to reinforce contextual understanding and familiarity with domain-specific problems. Avoid framing questions and checks-on-learning around trivial content; in other words, reinforce concepts and processes not acronyms.
- Keep learners moving; as often as possible, limit the amount of text, graphics, and narration on a single frame to require about 20-30 seconds of focused attention before moving to the next frame. This helps to maintain learners' interest and motivation.
- Limit on-screen text; we sought to use no more than a third of a page if text was necessary to support the presentation.
- Select images to serve a specific purpose, i.e., Soldiers engaged in actions related to the teaching point, and use commonly understood military symbols and graphics. We found VBS2 to be very effective to create graphical images and movies to support instructional points.
- Use legends or explanations to support more obscure selections of symbols and graphics.
- Organize the IMI content into brief encapsulated "chunks," and provide an overall structure content (e.g. hyperlinks) that learners can use to navigate (i.e., provide an advance organizer). Give learners control over how they move through the IMI.
- When progressing through IMI, take advantage of prior knowledge and skills. Use old, familiar concepts and terminology to introduce new, unfamiliar information.

- For sequential tasks, part-task assessment and feedback can be helpful to establish an understanding of the process being trained and the rationale for each step.
- Set task-based assessments in a specific context and relate them to real situations the learner may encounter (e.g., diagnosing and correcting mistakes in a previous leader's established defensive positions).
- Provide diagnostic assessment and feedback before training to assist learners in selecting appropriate content to maximize their learning, and after training to help learners plan for additional learning.
- Provide easy access to additional learning resources such as field manuals and technical manuals.

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Acronyms

ACU	Army Combat Uniform
AKO	Army Knowledge Online
ALM	Army Learning Model
ARI	Army Research Institute for the Behavioral and Social Sciences
BDU	Battle Dress Uniform
CCM	Close Combat Missile
CSS	Cascading Style Sheets
DOTD	Directorate of Training and Doctrine
ELO	Enabling Learning Objective
FDC	Fire Direction Center
FCoE	Fires Center of Excellence
FIST	Fire Support Team
HTML	Hypertext Markup Language
IMDP	Instructional Media Design Package
IMI	Interactive Multimedia Instruction
IOBC	Infantry Officer Basic Course
LCMS	Learning Content Management System
LMS	Learning Management System
MCoE	Maneuver Center of Excellence
MT2	MyTraining Tab
OSUT	One Station Unit Training
SCO	Sharable Content Object
SCORM	Sharable Content Object Reference Model
SGT	Sergeant
SSG	Staff Sergeant
TLO	Terminal Learning Objective
TLP	Troop Leader Procedures
TRADOC	U.S. Army Training and Doctrine Command
VBS2	Virtual Battle Space 2
WLC	Warrior Leader Course

APPENDIX A

INITIAL CRITERIA FOR EVALUATING EXISTING IMI

Initial Criteria for Evaluating Existing IMI

Criterion	Description
Complexity/Depth of Information Presented	Is there sufficient content to provide the desired coverage of the subject area, especially when attempting to form the different points of need training material?
Formal/Doctrinal Correctness (Experts' Perspective)	Is there anything that would raise subject matter experts' and/or trainers' concerns with the currency and accuracy of the material? Are there potential negative transfer issues?
Repurposable Graphics/Images	Are there alternative principles/ideas demonstrated by the same image/graphic? Are the graphics/images contextualized to guide how a Soldier is interpreting them?
Verisimilitude/Face Validity (Learners' Perspective)	Would Soldiers see the information and images presented as being accurate representations of current Army knowledge and practice (e.g., current doctrine, up-to-date uniforms, and current weapon systems)?
Viable Examples	How are examples being used and are there single or multiple examples? Multiple examples may be better to allow Soldiers to generalize principles by deriving consistent patterns across examples (cf. Schwartz & Bransford, 1998).
Narrative Flow	Does the narrative of the training make sense? Do instructional pages that come later logically build on what came before?
Presentation is Focused vs. Diffuse	Do the parts have a clear topical focus, or does the training meander?
Outcome Meets Goal	Does the training reasonably appear to accomplish established goals?
Grouping of Content	Are the modules and information grouped in a way that makes sense and provides a coherent structure (i.e., support development of schemas)?
Appropriate Testing	Do the tests legitimately cover the material at a conceptual level, or are they focused on insignificant details and off the subject area?
Interactivity/Control	In what ways is the Soldier being asked to interact with the training package, materials, etc.? Is the interactivity distracting to or supportive of the overall goals of the training? Is the Soldier given a sense of being able to shape his/her own learning process?
Timing	Would a Soldier be able to develop understanding of one learning point before the next one is presented? Are there logical points at which Soldiers can take a break from what they are learning?
Use of Prior Knowledge	Is prior knowledge elicited or refreshed before it is built upon?
Technical Characteristics	Are the requisite files available and in a format to be able to pull apart the training package? Is the software package that was used in developing the IMI courseware current and useable? Are the respective pieces of the courseware files able to be reconfigured within more current software?
Suitability for Tailoring	Does the courseware include aspects that would support various tailoring techniques (e.g., prompts based on thematic model, structuring presentation of elaborated/basic vs. advanced material, color cuing, pretesting and modifying learning presentation based on performance)