



Research Report 1990

**Using Technology to Support the
Army Learning Model**

**Joanne Barnieu
Ray Morath
Jonathan Bryson
Jessie Hyland
ICF International**

**Jennifer S. Tucker
Steve Burnett
U.S. Army Research Institute**

February 2016

**United States Army Research Institute
for the Behavioral and Social Sciences**

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**U.S. Army Research Institute
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Authorized and approved:

**MICHELLE SAMS, Ph.D.
Director**

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REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>		
1. REPORT DATE (DD-MM-YYYY) February 2016	2. REPORT TYPE Final		3. DATES COVERED (From - To) November 2013 – July 2015		
4. TITLE AND SUBTITLE Using Technology to Support the Army Learning Model			5a. CONTRACT NUMBER W5J9CQ-11-D-0002		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER 633007		
6. AUTHOR(S) Joanne Barnieu, Ray Morath, Jonathan Bryson, Jessie Hyland; Jennifer S. Tucker, Steve Burnett			5d. PROJECT NUMBER A790		
			5e. TASK NUMBER 0012		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) ICF International U. S. Army Research Institute 9300 Lee Highway for the Behavioral & Social Sciences Fairfax, VA 22031-6050 6000 6 TH Street (Bldg. 1464 / Mail Stop 5610) Fort Belvoir, VA 22060-5610			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U. S. Army Research Institute for the Behavioral & Social Sciences 6000 6 TH Street (Bldg. 1464 / Mail Stop 5610) Fort Belvoir, VA 22060-5610			10. SPONSOR/MONITOR'S ACRONYM(S) ARI		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) Research Report 1990		
12. DISTRIBUTION/AVAILABILITY STATEMENT: Distribution Statement A. Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES ARI Research POC: Dr. Jennifer S. Tucker, Fort Benning Research Unit					
14. ABSTRACT This research identified the successes and challenges of implementing technology in U.S. Army Centers of Excellence courses to meet the objectives of the Army Learning Model (ALM; TRADOC PAM 525-8-2). The findings provide TRADOC with insights of the facilitating and limiting factors that potentially affected the return on investment (ROI) of developing part-task and whole-task training products. Overall, there were more limiting factors found for the use and sustainment of part-task trainers which was due in part to the high-level of in-house capabilities and sustained interactions of stakeholders required for the planning and development of the products. For both categories of products, instructor training is a critical factor in maximizing the use, effectiveness, and the ROI of the products. Also for both categories of products, a significant finding was that little to no objective usage or student performance data was collected to verify that the products met the training intent, improved Soldiers' performance, and supported the tenets of ALM. Due to this lack of objective data, Army decision-makers lack a vital means of gauging whether these technology-based training tools support the successful implementation of ALM and, in terms of ROI, the extent to which the products were a sound investment.					
15. SUBJECT TERMS Training, Task, Return on investment, Training technology					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 35	19a. NAME OF RESPONSIBLE PERSON Dr. Scott E. Graham
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			Unlimited Unclassified

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Scott E. Graham, Chief**

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ACKNOWLEDGEMENTS

We would like to thank all of the individuals at the U.S. Army Centers of Excellence who participated in this research and for providing valuable input and feedback.

USING TECHNOLOGY TO SUPPORT THE ARMY LEARNING MODEL

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Using Technology to Support the Army Learning Model

Introduction

A key component of the Army Learning Model (ALM) is the application of technology to enhance learning. ALM indicates that technology should be leveraged to “make course content more operationally relevant, engaging, individually tailored, and accessible” (TRADOC Pamphlet 525-8-2, U.S. Army Training and Doctrine Command, 2011, p.12). This includes using emerging technologies such as mobile computing, open content, electronic books, augmented reality, gesture-based computing, and visual data analysis to improve learning. The ALM indicates that technology should be used in conjunction with face-to-face instruction (i.e., blended learning) as a means of expediting the learning process (TRADOC, 2011). Currently, the Army has been directed to “create a learning environment that enables mastery of fundamental competencies through an appropriate mix of live and technology-enabled learning methods” (U.S. Training and Doctrine Command, 2011, p.15).

In response to TRADOC Pamphlet 525-8-2 (2011), many of TRADOC's Centers of Excellence (CoEs) have established internal groups to design and develop technologies in support of ALM. The present research examined the effects of the development and use of technology products (e.g., by developers, instructional designers, course managers, instructors, students) within the CoEs and identified best practices and lessons learned for incorporating these products into courses in support of ALM. This work also supported TRADOC objectives regarding, 1) identifying factors that support or inhibit the development and use of effective technology products, and 2) presenting case studies representing both effective and ineffective design, development, and implementation of technology products.

Method

Senior leaders (e.g., Branch Chiefs, Directors) from eight Army Centers of Excellence (CoE) as well as the Training Brain Operations Center (TBOC) identified a broad and representative sample of technology products from their respective centers to include in the project ($N = 44$). They also completed product specification worksheets for the identified products which captured information regarding the most relevant dimensions and characteristics of each product (e.g., delivery method of product; knowledge/skill/ability focus of the product; course supported by product; single-user vs. multi-user/player; was product implemented in past 24 months).

The data from these worksheets were analyzed to identify a smaller subset of products for a case study analysis that varied across interactive multimedia instruction (IMI) levels and that were representative of each organization and of the Army's overall use of technology in support of ALM (TRADOC Pamphlet 350-70-12, 2013). The goal was to identify a representative sample that included both highly engaging and interactive products as well as products that offered a more passive experience (i.e., limited or no interactivity). The final sample that was selected for case study analysis consisted of 21 products from seven CoEs (see Appendix A for a more detailed description of the methodology).

Site visits were then conducted at each CoE to identify factors that facilitated or inhibited the successful development and implementation of each of the CoE’s sample products, as well as to determine the product’s effects on training developers, instructional designers, course managers, instructors and students. Interviews and focus groups were conducted with a total of 89 participants from across seven CoEs (see Table 1).

Table 1

Interview / Focus Group Participants

Positions	N
Training Developers	11
Instructional Designers	4
Course Managers	8
Instructors	21
Students	20
Participants in more than one role (e.g., instructor / course manager)	17
Other Personnel (e.g., forum facilitator, technical director, branch chief)	8
Total	89

Results

The interview responses were first analyzed by IMI level to provide insights into the successes and challenges of developing and implementing technology products in CoE courses specific to that level of interactivity (see Appendix A for the methodology and results by IMI level). Common themes also were determined across all of the IMI levels and offer a broader perspective of the overall challenges of developing and implementing technology regardless of the specific level of interactivity (see results in Appendix B).

In order to best determine the potential return on investment (ROI) for the CoEs when deciding to develop and implement a technology product in a course, facilitating and limiting effects on ROI were determined for part-task (16 level 2 and 3 IMI products) and whole task (5 primarily level 4 IMI products) trainers. An example of a part-task trainer would be a computer-based training or mobile application instructing students on how to perform specific tasks in a guided manner. A level 4 IMI product can be a part-task trainer if it’s a highly interactive product yet not representing the full functionality of the equipment (covering all tasks). A level 4 whole-task trainer product is generally termed a simulator which covers all tasks related to the equipment. An example of a whole task trainer would be an aircraft simulator. The simulator resembles the actual equipment (hardware and software), allowing students to interact with it to complete all tasks related to that equipment.

Table 2 focuses on part-task trainers and lists both facilitating and limiting factors to a high quality product in support of ALM. For each facilitating and limiting factor listed, corresponding ROI effects are described in detail. The facilitating factors include front-end analysis, subject matter expert (SME) involvement, editable software, accurate visuals of

equipment, creative instructors, and a train-the-trainer approach. The limiting factors include lack of front-end analysis and stakeholder consensus, limited SME involvement, lack of POI integration and product ownership, difficulty maintaining the products, lack of formal instructor training on the products, and lack of objective data collected on training effectiveness or the need for product modifications. Out of the 16 part-task trainers developed, 7 were being used as part of a course as stated by instructors.

Table 2

ROI Effects of Facilitating and Limiting Factors for Part-Task Trainers

PART-TASK TRAINERS	
Facilitating Factors	ROI Effects
<i>Front-end & On-going Analyses</i>	
Performing front-end analysis/ assessments throughout the product development cycle: (1) collaborative meetings being held with SMEs, Stakeholders (leadership), Training Developers, Instructors, and Course Managers, (2) Training Developers observing classes and identifying strategies based on these observations, and (3) identifying training needs via assessing or observing students	The stakeholders could properly identify resources needed for the project, including whether to develop the product in-house or use a contractor. Front-end analysis also established technical requirements (i.e. identifying appropriate software).
	The products met the training intent since training needs were identified during the analysis. This led to increased use of the product in the classroom.
	Collaborative meetings kept everyone on the same page so that the end product met the stakeholders' vision.
<i>SME Support</i>	
Availability of and accessibility to the same SME's throughout the product development cycle	SMEs provided accurate and relevant input at critical points in the products' development. They provided feedback during the development cycle so that developers could make appropriate modifications in a timely manner. Accurate and relevant products led to increased use in the classroom. Timely SME feedback reduced lifecycle costs and put products in the hands of instructors and students soon to better support the achievement of learning and course outcomes.
<i>Technology Specifications</i>	
Using editable software with skilled / qualified in-house personnel	Editing software in-house increased the CoE's ability to maintain the products when changes were required rather than paying for contractor support. Reduced product 'down-time'.

Table 2 (Continued)

Using accurate visuals of equipment including the inside of a device or piece of equipment (i.e. using 3-D models)	Increased the retention of information and recognition of components when working on live equipment.
<i>Instructor Use/Application</i>	
Using intuition and creativity to implement the product [despite lack of Program of Instruction (POI) integration]	Instructors leveraged the products in a variety of ways to address learning objectives (i.e., products used for course preview or review, homework, instruction, practice, remediation or refresher). Instructors also used products to generate discussion or foster peer to peer learning in the classroom.
<i>Instructor Training</i>	
Using a train-the-trainer approach to disseminate information about the product and its best use	Increased the use of the product in the classroom and facilitated optimal use/application of products as opposed to instructors learning the product's capabilities through 'trial and error' or not using the product.
Limiting Factors	ROI Effects
<i>Limited Front-end analysis</i>	
Lack of front-end analysis (no training analysis, vague requirements or customer-dictated requirements)	Resulted in issues with manpower / resources for product development and sustainment and maintenance of the product (e.g., an in-house development team lacked training and experience in the software chosen to develop the product).
	Products developed were not instructionally sound, relevant, accurate, sustainable (editable), engaging, or did not meet the training intent. This led to a decreased use of the product in the classroom.
<i>Stakeholder Consensus</i>	
Lack of stakeholder consensus for product requirements	Stakeholder expectations were not met. For example, leadership may have envisioned a high-end simulation, however, the development team produced a level 2 or level 3 IMI product (which may have met training intent and was within budget but did not meet leadership's vision).
<i>SME Support</i>	

Table 2 (Continued)

<p>Limited access to the right types of SMEs during product development (i.e., those with relevant knowledge and experience)</p>	<p>Decreased the fidelity and accuracy of scenarios and/or simulated equipment. For example, an inexperienced SME did not accurately describe the tactics for a specific combat mission during scenario development. Thus, the product was seen as inaccurate or obsolete and its use was decreased in the classroom.</p>
<p>Limited access to SMEs providing timely input and feedback</p>	<p>Product development was delayed during the initial prototype development as well as post-prototype development when SME feedback was required for finalization.</p>
<p><i>POI Integration</i></p>	
<p>Lack of integration of the product into the course POI</p>	<p>Products were viewed as optional. In some cases, instructors were not aware of the product, leading to decreased use of the product. In other cases, products were used in different ways by different instructors, which meant that students did not experience the product in the same manner across the course. For example, if an instructor was using the product as a means for discussion and peer to peer learning, those students were experienced ALM via the application of the product. Another instructor may have not used the product at all or only used it as a self-directed learning, rendering it a less engaging exercise.</p>
	<p>If a product was not used for instruction, then no ROI can be achieved for the Army.</p>
<p>Lack of ownership of the product (i.e., individuals who follow through with its implementation and inquire about its use or need for modification via monitoring or request for feedback)</p>	<p>Without ownership of the product, it was difficult to communicate its existence and its value to other instructors. In some cases, instructors were not aware of the product, how to access the product, and / or how to use the product (lack of training).</p>

Table 2 (Continued)

	Without monitoring, it was difficult to ensure the products were being used as intended for instruction, were reliable, and that the content was accurate and relevant. Identification of bugs or feedback on product accuracy/relevance occurred via ‘happenstance’ or via feedback from students/instructors resulting in student/instructor frustration with product.
<i>Technology Specifications</i>	
Using software that was not editable; or not having the in-house capability to work with the software	Without editable software, there was a reliance on the contractor to support changes, which led to delays and issues with maintenance contracts. When no maintenance contract was in place, the products were not updated, thus instructors were not using the products or students were using products with inaccurate or obsolete information.
	Without in-house capability to update the software, delays occurred in making the edits or products were not updated, thus instructors were not using the products or students were using products with inaccurate or obsolete information.
<i>Instructor Training</i>	
Lack of formal instructor training on how to integrate products into lesson plans	Instructors relied on other instructors to train them on how to use the product and the best way to integrate the product. If the instructor who trained the other instructor did not know the full potential of the product, then this information gap was passed on to the next instructor.
	Without formal training on the products, instructors did not use the products consistently. This led to students not receiving the same experience. For example, some instructors used the products to generate discussion and peer-to-peer interaction, which led to a more engaging experience for those students as opposed to students who used the product in a self-directed manner.
<i>Evaluation</i>	
No objective student outcome data collected on products	Unable to determine the products’ training effectiveness, support of ALM, or ROI.

Table 2 (Continued)

<p>No formal mechanism in place to collect or capture feedback on products from instructors and students concerning content accuracy, relevance, or system bugs (not explicitly part of course critiques)</p>	<p>Without feedback, it was difficult for individuals charged with maintaining products to know when content issues needed to be addressed and made it harder for them to fix problems quickly when they arose. When errors and bugs persisted in a product over extended periods of time, instructors and students tended to not to use them (i.e., viewed them as inaccurate or obsolete products).</p>
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Table 3 focuses on whole-task trainers and also lists both facilitating and limiting factors to a high quality product in support of ALM along with associated ROI effects. These products were developed by contractors. Facilitating factors include the use of products as a way to prepare for live equipment as well as onsite contractor support to assist with training and troubleshooting. In addition to similar limiting factors as found with part-task trainers, other limiting factors include issues with maintenance contracts as well as little performance feedback provided from the product itself which requires instructor monitoring of student performance and increases instructor workloads. Out of the 5 whole task trainers developed, 4 were being used as part of a course as stated by instructors.

Table 3

ROI Effects of the Facilitating and Limiting Factors for Whole-Task Trainers

<p>WHOLE-TASK TRAINERS</p>	
<p>Facilitating Factors</p>	<p>ROI Effects</p>
<p><i>POI Integration</i></p>	
<p>Use of products as the “walk” phase of the Army’s crawl, walk, run training method.</p>	<p>Students were provided opportunities to practice before being tested on the actual equipment. The products helped bridge the gap between instruction and live equipment.</p>
	<p>Instructors were able to make use of downtime to provide struggling students opportunities for more practice.</p>
	<p>When there was only a limited amount of live equipment available for use, instructors were able to make use of downtime to provide practice opportunities for students who were waiting to get on the live equipment.</p>
	<p>Since students were able to practice on the simulator and achieve mastery, this resulted in less wear and tear on actual equipment (less breakage), reduction in live rounds fired or less fuel used.</p>
<p><i>Product Updates</i></p>	

Table 3 (Continued)

Contractor support onsite and available for training instructors and troubleshooting issues that arose during class time	When the contractor who developed the product was onsite, the training which instructors received was more robust, and the instructors were trained on the full potential of the product. For example, instructors were shown how to pull data from the simulators to measure performance and provide feedback.
	During class time, when there were system shutdowns or other technical issues, these problems were quickly addressed, leading to less student wait time to bring systems back up to full functionality.
Reduction of training time on the live equipment	By reducing training time on the live equipment, ROI is positively affected. Some of the examples of the effects on ROI included a reduction of wear and tear on the live equipment as well as reduction in fuel costs as it pertained to time needed in aircrafts (since students were already prepared and did not need to train on fundamental tasks).
Limiting Factors	ROI Effects
<i>Contractor Support</i>	
No maintenance contract in place	Products were updated in a very limited manner depending on in-house capabilities or they were not updated at all. Obsolete or inaccurate products led to negative training and frustration for students who are familiar with the equipment. To avoid negative training or student frustration, instructors did not use the product in classroom.
<i>POI Integration</i>	
Lack of integration into the course POI	Instructors customized and adapted scenarios to meet different learning objectives in order to maximize impact on training effectiveness. They had to use their own experience or intuition or rely on another instructor for guidance.
<i>Instructor Training</i>	
Limited formal instruction on how to integrate the simulator into the lesson	Instructors used the simulators in different ways or did not use simulators to their potential. This led to inconsistent experiences for the students.
<i>Student Feedback</i>	

Table 3 (Continued)

<p>Products provided minimal real-time feedback to students regarding their performance</p>	<p>When the products did not have an embedded after action review (AAR), the instructors were required to monitor student performance using computer monitors, video footage, and data generated from the simulator in order to measure performance and provide feedback. This led to increased instructor workloads, and some instructors were not monitoring student performance or conducting limited monitoring. Further, some instructors did not know how to pull performance data from the simulators, resulting in students who did not receive feedback on their performance.</p>
<p><i>Evaluation</i></p>	
<p>No objective student outcome data was collected on products</p>	<p>Unable to determine the products' training effectiveness, support of ALM, or ROI.</p>
<p>No formal mechanism in place to collect feedback on products from instructors and students concerning content accuracy, relevance, or system bugs (not explicitly part of course critiques)</p>	<p>As with the part-task trainers, without feedback, this made it more difficult for individuals charged with maintaining products (in this case, the contractors) to know when accuracy issues or bugs needed to be addressed. Thus, making it harder for them to fix problems quickly when they arose. When errors and bugs persisted in a product over an extended periods of time, instructors and students tended to not to use them (i.e., viewed them as inaccurate or obsolete products).</p>

Success and challenge stories are reported below that provide exemplars of the facilitating and limiting factors presented in Tables 2 and 3. The stories are supported by statements made during interviews and focus groups.

Success Stories

Part-task trainer. After receiving notification from the Commanding General that Soldiers needed to learn about making decisions while thinking about the 2nd and 3rd order effects, an in-house development team held a structured meeting which included instructional designers from the multimedia branch as well as training developers, and SMEs. Although the development of the product was not based on a formal analysis (i.e. a training gap analysis), the design was supported by an informal analysis during which SMEs supplied scenario ideas, and the multimedia team discussed technologies that could support the execution of these scenarios in the most effective manner. It was indicated that the team had benefited greatly from that initial meeting.

Based on those discussions, the multimedia team selected VBS2 (Virtual Battlespace 2) to record the scenarios that would play out based on the student's decision. Using this

technology instead of live video facilitated editing and allowed the scenarios to contain more graphic scenes which provided the most impact on the student. The in-house team was successful in coming up with innovative and creative ideas to support the needs mentioned in the meeting.

The branch had a process in place for requesting SMEs, so they were able to obtain dedicated SMEs. The SMEs continued to work with the multimedia team throughout the development of the product and were capable of providing specific input required for the development of scenarios.

Part-task trainer. This product was installed on Blackboard, allowing for the usage tracking of the training product. As with other products that were examined, this product was designed to support the “walk” phase of the “crawl, walk, run” cycle. This allows instructors to observe the transfer of skills when students are working on live equipment. It was indicated that there was a good transfer from the training product to the actual use of the equipment and that students were more confident conducting training on the live equipment. Although knowledge and skills transfer data was not formally collected via assessment scores, the product developed to support the “walk” phase allowed for performance evaluation on live equipment, which reflects a level three Kirkpatrick evaluation (Kirkpatrick, 1994, 2006).

Whole-task trainer. This product was implemented after instructors received training from the product developers (contractors in this case). The product used a station for instructors to monitor the students’ use of the product during classroom time in order to provide feedback and support. The training the instructors received included how to set up and use the monitoring stations to see how the students were doing and help when needed. The instructors could also inject faults into a team’s scenario to assess troubleshooting skills, and the instructors were trained on how to do this by the contractor. The multi-user technology product supported peer-to-peer interaction as this was noted by instructors as they moved between monitoring stations and observed students helping other students during the activities. The contractors who developed the product are on site and available to troubleshoot any issues that arise.

Challenge Stories

Web-based training application. This particular IMI product was developed due to a need to revise components of the course. The Course Manager and instructors decided to use an IMI product to instruct a particular portion of the course. This was the extent of the analysis to create a technology-based solution. They outsourced this to a contractor and did not discuss with the contractor what level of interactivity was envisioned. It was indicated that the conversation with the contractor would have been different had ALM been implemented at that time. Due to contract delays, the instructors created PowerPoint slides as an interim solution. When a new vendor was contracted, their team did a straight conversion of those PowerPoint slides. Since this was a basic IMI, instructors did not require training on how to incorporate this into the classroom; however, the product’s usage by instructors diminished over time. Currently, the IMI is not being used as the primary method of instruction; it is now a secondary source with lecture being used to teach the concepts. It was reported that the students who did use the IMI seemed to not have understood the IMI content.

Mobile application (job aid). This particular product was designed as a support tool for students. Although the product was interactive and was designed to be “just in time” training support through use of mobile devices, this product was not integrated into the course POI and viewed as optional. The product was designed by skilled contractors who had gaming and mobile technology expertise which led to engaging products in support of ALM. However, students were not aware of the product unless they were told about it by other students, by an instructor who saw value in it, or if they saw it could be downloaded from Milsuite. Furthermore, its usage was not tracked by instructors; therefore, students who were aware of the product knew it was optional.

Mobile application (job aide). For this product, usage or student performance data were not able to be collected or tracked because the products did not reside on a learning management system (LMS). Further, there was no formal follow up as to whether a student performs better after using these support tools. The feedback was only provided via an email box which was set up to gather reaction-based comments (with some content-based comments); these were then reviewed by the development team. No means existed to demonstrate training effectiveness with hard data, thus, the ability to determine the effects of using the technology for Army training was limited (i.e., limited ability to determine ROI effects).

Discussion and Conclusions

A cross-walk of the factors for the part-task and whole-task trainers indicated that none of the facilitating factors overlapped. This may be due in part to the idea that Army personnel (both military and civilians) were actively involved in the planning for and development of the part-task trainers. Thus, many of the facilitating factors appeared to be related to the activities involved in planning and developing the products (e.g., performing analyses, availability and accessibility to SMEs, using editable software with skilled/qualified in-house personnel). On the other hand, for the whole-task trainers, the front-end analysis is typically conducted as part of a larger Army material acquisition process. In this case, comprehensive DOTMLPF (Doctrine, Organization, Training, Material, Leadership & Education, Personnel, and Facilities) studies are conducted which feed into the JCIDS (Joint Capabilities Integration Development System) process. The individuals who participated in this research may not have taken part in that process or assumed their positions long after these processes occurred. Consequently, the facilitating factors for the whole-task trainers reflected the use of the products while executing the course (e.g., Use of products as the “walk” phase of the Army’s crawl, walk, run training method, contractor support on site) and the positive effects on ROI by reducing the amount of training time needed on live equipment.

The limiting factors that potentially affect ROI were essentially the opposite of the facilitating factors. That is, if no front-end analysis was conducted for the part-task trainers, then this potentially has negative effects on the ROI in that the products developed were more likely to be inaccurate or not instructionally sound and thus not used in the classroom. For the whole-task trainers, one limiting factor is the lack of a maintenance contract which is the opposite of having onsite contractor support. Thus, there were many more limiting factors for the part-task trainers due to the many different issues that arose during the planning and the development of

the products often using in-house capabilities and resources. For the whole-task trainers, the planning was likely accomplished with very large teams of personnel and the development accomplished by contractors offsite and delivered to the Government.

One limiting factor that was identified for both product categories was a lack of instructor training. A total focus on the technology development will not necessarily lead to successful implementation or high-level of use in the classroom. A systematic process for training new instructors on how to use the full capabilities of the products, how to best use the products to support the course outcomes, and how to best address challenges that occur when students are using the products is critical to maximize the effectiveness and ROI of the products.

When the facilitating factors were compromised and/or the limiting factors were present, challenges arose for these products—ultimately leading to less effective use of the product, decreased use of the product, or even no use of the product in the classroom. The findings indicated that 44% ($n = 7/16$) part-task versus 80% ($n = 4/5$) whole task trainers were being used in the classroom or to support some other learning event. Nearly all of the whole-task trainers were being used in the classroom despite the lack of a maintenance contract in some cases (indicating a lack of updates to keep the product relevant and current). Thus, although the front-end costs of developing whole-task trainers can far exceed those of the part-task trainers, these products have a much better chance of being sustained in part due to the extensive front-end analyses that are conducted to obtain requirements, SME involvement, systematic reviews to ensure requirements are met, and often POI integration.

Further, the factors for the part-task trainers leading to positive outcomes are closely aligned with a successful employment of the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model for training-based interventions. Those products which were developed based on a front-end analysis with SME input and supported by effective instructor training and communication were used more in the classroom and used in ways which support ALM. As evidenced in the success stories above, when the Army employs the ADDIE model to the fullest extent possible during instructional materials development or revisions, the outcome leads to a solution which supports the intent, in this case supports ALM. If the intent is to produce instructional material or a product that supports Soldier-centered training, peer-to-peer collaboration, or critical thinking skills, among other initiatives, adhering to the ADDIE model will generate the best outcome for this intent. Those products which were developed without or with little front-end analysis and limited SME input were at a higher risk for being inaccurate, obsolete, and unable to meet the training intent, leading to decreased or no use in the classroom.

For both categories of products, a significant finding was that little to no objective student performance data was collected to verify that the products met the training intent, improved Soldiers' performance, and supported all or some of ALM tenets. Due to this lack of objective data, the CoEs and the Army lack a vital means of gauging whether these technology-based training tools are supporting the successful implementation of ALM. In terms of ROI, when the evaluation phase of the model is not executed at all (or even in part), it is challenging to determine the extent to which the instructional material or product was a sound investment. This creates a challenge for sustainment and considerations of manpower and resources for the future.

A plan that specifies how the evaluation will be conducted and what resources are needed to conduct an evaluation of the product is needed to be agreed upon by stakeholders at the beginning of the technology product planning and development process. “After the fact” evaluations typically do not give the decision-makers the information they need or desire (e.g., no baseline information, subjective data from instructors regarding student learning with and without the technology).

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Appendix A:

Research Method

The purpose of this project was to identify and examine a sample of technology-based training products developed and/or implemented by seven Centers of Excellence (CoEs)¹ and the Training Braining Operations Center (TBOC) in an effort to identify lessons learned and best practices for incorporating these products into courses to support the Army's new Learning Model (ALM). This was accomplished in two stages.

Stage I: Sampling of Training Products

CoEs were tasked with identifying a representative sample of technology-based training products that were either developed for and/or implemented in a course at their respective centers. For each product identified they completed a product specification worksheet that captured the most relevant dimensions and characteristics of each product (see Figure 1). Once all worksheets were returned, follow-up conference calls were scheduled with each CoE to address information gaps in the worksheets and to request copies of each product, as well as any supporting materials that might have been available (e.g., user guides, training manuals). During these efforts, 44 technology-based solutions were selected for further study, with each organization contributing approximately three to six products.

The information from the products was analyzed to identify how each of the technology-based training products varied across the dimensions/characteristics captured within the product specifications. The goal was to identify a diverse set of products that best represented each organization and that varied across interactive multimedia instruction (IMI) level. This included both highly engaging and interactive products as well as those that offered more of a passive experience (i.e., limited or no interactivity). Based on this analysis, a representative sample of technology-based training products were selected from each organization for inclusion. A total of 21 products were selected for the final sample, with each organization contributing approximately three technology-based training solutions.

¹ The Mission Command Center of Excellence (MSCoE) at Ft Leavenworth, Kansas was excluded from this effort. TBOC also was excluded from the data collection due to its unique role as a resource for each of the CoEs.

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SUBJECT: TRADOC TASKORD IN140362 Army Research Institute Study on Using Technology to Support the Army Learning Model

Product Specification Worksheet	
PRODUCT NAME:	
SHORT SUMMARY OF PRODUCT (i.e., goal of the product /gap product is intended to fill):	
Evaluative Dimensions	Response (Responses are not limited to the space)
1) Please specify the delivery method/product type. For example, it may be a game-based training, simulation/virtual scenario, traditional e-learning, virtual classroom, etc.). The training may also be desktop or mobile.	
2) Please describe the skill/ability focus of this product and/or learning gaps addressed by the product. Does the product focus on the acquisition of declarative knowledge (terms, facts, rules concepts), procedural or demonstrative knowledge (how to perform a procedure), decision-making or critical thinking, or psychomotor skills (how to perform physical tasks such as manipulate a piece of equipment).	
3) In which course(s) is the product currently being used?	
4) Is the product single-user or multi-user/player (i.e., virtual environment in which multiple players can interact with one another)?	
5) Does the product include an instructor authoring tool? If so, is the interface for this authoring tool accessible to and easy to use for instructors?	
6) Does the product include a complete instructional cycle (e.g., pre-assessment, didactic portion, demonstration, practical exercise (scenario /simulation), post-assessment, and After Action Review)? If not, which component is missing from this cycle?	
7) Was the product implemented in the past 24 months?	
8) Was this product developed in-house? (If not, who developed the product? Who is maintaining it?)	
9) Please describe design and development constraints faced such as time, funding, etc.	
10) Please describe challenges faced in implementation of the product (may be technology-related or any challenges in general).	

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Figure A1. Product Specification Worksheet.

Stage II: Data Collection

The research team then conducted data collections at each CoE to identify best practices, lessons learned, and challenges associated with the development and implementation of each technology-based training product, as well as the effects of these products on the curriculum, training developers, instructional designers, course managers, instructors, and students. The following research questions were examined.

1. How well equipped are the technology-based training development organizations (TTDOs) for developing training solutions that support ALM?
2. What was the impact of products on curriculum?
3. What was the impact of products on instructors?
4. What was the impact of products on students?
5. What was the impact of the product on course managers/leaders?
6. What was the impact of the product on training developers/instructional designers?

Participants. A sample of 89 participants from the seven Army CoEs were interviewed or participated in focus groups. This sample included training developers, instructional designers, course managers, instructors, students and other personnel (e.g., forum facilitator, technical director, branch chief) experienced in or involved with the development and/or implementation of technology-based training solutions at their centers.² Table 1 displays the number of participants by category.

Procedure. Interviews and focus groups were conducted at each CoE and lasted approximately 60 minutes. All participants received informed consent forms to review prior to being introduced to the project and their rights as participants were explained (e.g., voluntary participation). Participants were then asked a series of questions based on their experience with a particular technology product using a semi-structured interview protocol. The protocol was divided into the following four primary sections and consisted of 38 questions.

1. Description of the technology-based training product and the ALM concepts it supported (3 questions). For example, “Please describe the instructional delivery method (technology-based or otherwise) explain its use in the course” and “Which of the following ALM concepts are supported by this instructional delivery method?”
2. Development of the product to include the process used to identify the need for the product (5 questions). For example, “What course learning objectives are addressed by this instructional delivery method?” and “To what degree were students, instructors, technical experts, job incumbents, and other SMEs involved in the development of this instructional delivery method?”
3. Implementation of the product and its impact on those involved in the process (11 questions). For example, “How prepared were you to implement the new instructional delivery method once it was inserted into the course?” and “How does this instructional delivery method impact students?”
4. Challenges, lessons learned, and best practices associated with the product (5 questions). For example, “What were some of the significant challenges faced in developing / implementing / maintaining this instructional delivery method?” and “From your experience, what are some best practices for the future when developing / implementing / maintaining an instructional delivery method in support of the ALM?”

In addition to the four main sections, there was a section set aside specifically for students which consisted of many of the same questions found in other parts of the protocol (14 questions). For example, “Now that you’ve had a chance to use the instructional delivery

² Please note that there were 17 participants involved who held more than one role (e.g., instructor/course manager, training developer/instructional designer)

method, has it met your expectations?” and “Does using this instructional delivery method help you to feel more engaged in the training?” Figure 2 provides a copy of the protocol used during the data collection.

Analysis. A content analysis was conducted using the Analysis, Design, Development, Implement, Evaluate (ADDIE) model as a framework to help structure theme identification. A five step process was used.

Step 1. Transcripts were sorted by product IMI level. IMI level in this context refers to the level of interactivity between the product and the learner; with level 1 being the lowest level of interactivity and 4 being the highest. A level 1 product is often referred to as a “page turner” due to the passive nature of the learning and Level 4, on the other hand, consists of products that provide a much more immersive experience for the learner. Table A-2 displays the number of technology products included in the analysis for each IMI level.

Table A1

Products by IMI Level

IMI Level	<i>N</i>
Level 2	7
Level 3	9
Level 4	5
Total	21

Step 2. A large sample of interviews and focus group transcripts was reviewed and content analyzed to identify thematic categories or codes within each IMI level according to each phase of the ADDIE model.

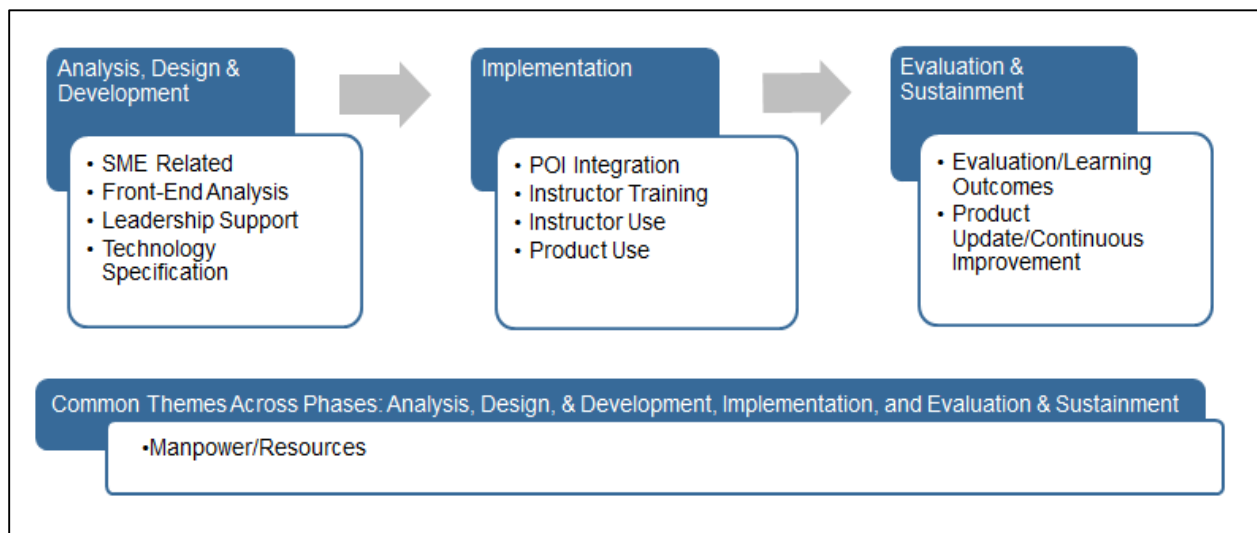


Figure A-2. Common theme categories identified for each phase of ADDIE model.

Step 3. The thematic categories/codes described above were then used to sort the content in each transcript. Coding was conducted at the product level to control for methodological issues that could potentially arise from coding at the participant or session level.

Step 4. Coded themes were then reviewed for each product by IMI level in order to identify those that were common. A theme was considered common when it was found in at least 50% of products for a given IMI level. For example, if a theme was identified in 5 of 9 level 3 products (i.e., 56%), it was counted as a common for that level. The results from this effort are found in Appendix B.

Step 5. Common themes for each IMI level were then reviewed to identify common themes across IMI levels (see Appendix B).

Appendix B:

Cross-Cutting Themes and Themes by IMI Level

As mentioned in the executive summary report, we analyzed products grouped within their respective IMI levels before extracting common themes across all products. In this appendix we provide a detailed list of the cross-cutting themes as well as a list of themes sorted by IMI level. These themes are presented in accordance with the phase of the ADDIE model. These themes were extracted using our methodology as described in Appendix A. These themes also were used to develop the facilitating and limiting factors potentially affecting ROI.

Cross-Cutting Themes

Analysis, Design, Development

Analysis prior to product design / development. The results indicated that training developers did not perform or performed very little front-end analysis before the products were designed. Front-end analysis can include various steps depending on the desired outcome yet most commonly includes a needs assessment which identifies the learning gaps to be addressed by the intervention. Different organizational resources are required during the analysis phase (i.e. stakeholders, developers) to determine what these gaps are and the best manner to address them. For course revisions, often the gaps were already identified during the development of the original course; therefore, the analysis may focus more on revising the instructional approach (i.e. delivery method).

When there is no or little up-front analysis, there is a risk that training interventions are not systematically aligned with identified learning objectives. Furthermore, if it is the institution's intent to roll out new instructional approaches (such as supporting the ALM), front-end analysis is essential to ensure the design supports the new or different instructional approach.

Front-end analysis should include a team meeting to discuss the learning gaps and potential interventions. This allows a consensus to be reached on the best options and to plan for resources, manpower, implementation, and sustainment. Without this type of meeting, an intervention may be developed that does not meet the intent, withstanding issues of resources, manpower, implementation, and sustainment.

The results demonstrated a few best practices that certain CoEs had implemented. In one case, there was an up-front collaborative meeting with stakeholders, senior leaders, and developers to evaluate the training need, explore options, and discuss product requirements. In another case, training developers observed classroom instruction prior to the product development in order to determine the best instructional approach for the POI revision.

Access to and availability of SMEs. Development of instructional materials depends largely on information provided by an individual (or group of individuals) who has expert knowledge of the subject matter or proven expertise in the task. During the development phase, access to these individuals is crucial since lack of access can stall the development cycle and can threaten the fidelity, accuracy, and relevancy of the training intervention. The results suggested

that access to SMEs or to the same SMEs throughout the development cycle was a recurring challenge. SMEs who provided valuable input and demonstrated dedication to the project were often sought after by other organizations, thus inaccessible from the onset or becoming inaccessible in the middle of the development.

On the other hand, the results indicated that when there was a process in place to access and maintain the same SMEs throughout design and development, the outcome met the desired intent.

Manpower and resource constraints. As previously mentioned, issues of manpower and resources can be the result of a lack of analysis pertaining to the intervention requirements. If a team does not collaboratively discuss intended outcome, budget, and technology requirements, the development team can face issues of manpower and budget to complete the product. The results suggested fundamental issues of manpower and resources for both in-house and contractor development. For in-house development, there appeared to be a lack of manpower to support technology-related projects as well as issues related to the qualifications and experience of those working on technology development. When a contract was used to develop the product and a requirement for the maintenance of the product was not specified then challenges were reported in obtaining the necessary updates to keep the product current and relevant.

The results indicated a best practice of using development software that is editable in-house (i.e. Unity which is open source and html-based code). This requires in-house training developers to be skilled in working with the software. Contractors who used Unity to develop the training product allowed for a maintenance strategy in-house rather than relying on the contractors to make any necessary updates.

Implementation

POI Integration. As mentioned above, the lack of front-end analysis leads to interventions that are not systematically aligned with learning objectives. This result was evident in the findings that many products were not incorporated into course POIs and were often considered optional instructional tools or ones in which the instructors used in a variety of ways to achieve learning objectives. If product use is not enforced, this leads to an inconsistency in the degree to which students experience the ALM instructional approach. If use of the products is not standardized, and instructors use them in different ways, then there is a risk that students are not experiencing ALM in the same manner or not experiencing all of the ALM tenets. For example, one instructor may use the product as a way to facilitate peer to peer interaction and instruction, whereas another instructor may use it only for self-directed learning. The students in these two classes are not having the same experience with ALM.

On the other hand, it was interesting that some instructors were proactively using products that were optional even if they were using them in different ways. This reveals that instructors found the products useful in supporting learning objectives even if not tied to the POI.

Instructor training. The amount of training required for the instructors varied by product, since some products required more training on the actual use of the product (i.e. IMI level 4 products /simulators) while others required training on how to incorporate the product into the course. IMI level 2 products generally did not require instructor training since these products were mostly self-explanatory (web-based eLearning). However, it was evident in the data that, even in cases when training was required, it mostly did not occur in a formal or structured manner or did not occur at all. When instructors are not trained on a product they may spend class time attempting to work with the product and thus lose valuable instruction time. They may also not use the product to its fullest potential, thus not providing the maximum benefit of the product's capabilities to the students. Finally, if the instructors do not know how to use the product they will likely avoid using it at all, especially if use of the product is not incorporated into the POI.

When instructors are trained informally on a product (i.e. instructors may give other instructors a run-through), they are at least "brought up to speed" on the product's capabilities; however, this can lead to an inconsistency in how instructors are trained. An instructor is only as knowledgeable about the product as the instructor who showed him or her. If that instructor is does know the product's full functionality, the other instructor also will not be aware of the product's full capabilities. Likewise, another instructor may end up using it to its fullest potential since he or she was taught by a different instructor who was more familiar with the product. This varied use of the product affects the students, such that there is no consistency in how the students experience the product or ALM.

The results indicated that the products developed by contractors sometimes included training support, and instructors were more formally trained on the product. This was the case mostly with IMI level 4 products that included instructor monitoring stations and the need for instructors to bring up systems and troubleshoot issues.

Product use. If products were not systematically incorporated into the course POIs and instructors were not trained on how to use the product, then the results indicated that the instructors used the products in different ways to support the instruction of specific learning objectives. In a sense, benefits to the students relied on the creativity of the instructor. For example, some instructors used the products to preview or review the material in the lesson, such as during homework, as actual instruction (in place of using lecture and slides), or during downtime in class. For instance, if students were waiting to use live equipment, they were able to use the product to maximize their time spent in class.

When an intervention is used in different ways, there is a risk that the intervention outcomes will not meet the original intent or plan. During the Analysis and Design phases, interventions are often conceptualized based on the intent to address an identified training gap. If the intervention is used in a different manner, there is a risk that this intent will not be met.

One best practice involved training developers who observed the instructors using the product in the classroom and provided feedback on how it was used. This monitoring and feedback practice helped to minimize the risk that the final products would not meet the intent.

Evaluation and Sustainment

Evaluation. Objective student performance data was not collected for these products. Some reaction data was collected through course critiques. Without hard data reflecting training effectiveness, the organization cannot determine the ROI of the intervention. When evaluations are not conducted it also is difficult to obtain feedback on what modifications or enhancements are needed.

Our findings show, however, that subjective data were gathered through informal means. In many cases, instructors could simply “tell the student used the product” based on how the student performed in the subsequent lesson or how they performed on live equipment. Although from subjective data, these results suggested that the products supported the learning objectives.

Product updates. Challenges with product updates depended on whether or not the product was developed in-house or by a contractor. When products were developed by contractors using proprietary software or software that in-house developers were not trained on product updates were delayed or could not be performed without sustainment contracts in place.

If students use products that are outdated (including simulators), there is a risk for negative training, a potential loss in student engagement, and an increase in student frustration with outdated instructional material.

When contractors used software that could be edited in-house (i.e. html-based Unity), this allowed for an in-house maintenance strategy rather than a reliance on contractors to make any necessary updates. Ultimately, an investment in in-house development could minimize the abovementioned risks and impacts.

Themes by IMI Level

Level 2 IMI Product Themes

Level 2 IMI. These products require the user to recall more information than a level 1 IMI product (i.e. a lesson in linear format). Users have more control over the lesson content through icons and other peripherals and are generally assessed using simple assessment items such as multiple choice questions. Data were collected on seven level 2 IMI products.

Analysis, design, and development

SME-related. For 100% of the products, it was reported that it was critical to have the right SMEs involved at the right phases of design, development, and testing products. The right SME is not only a content expert; he or she can also be an instructor, instructional designer, multimedia expert, actor, or videographer.

For 5/7 products (71%), it was reported that SME turnover created challenges to the timeline, scope, and budget of the training product development. It is important to have the same

set of SMEs available throughout the product development cycle. In some instances, strategies were mentioned to mitigate this challenge such as having multiple SMEs assigned or having thorough documentation throughout the design and development process.

Front-end analysis. For 6/7 products (86%), the need for the training was linked to a performance concern or training gap identified either through observation or testing (e.g., students were reported as having trouble performing actions or being weak in certain areas; portions of the instruction required modification; students needed more opportunities to learn about the equipment since there were not enough simulators).

Leadership support. For 4/7 products (57%), leadership buy-in from the onset through implementation was vital to the success of the product. Buy-in includes a general consensus on the need for the product and the vision of what its final outcome should be. It was also reported that leadership changes during the product development lifecycle produced challenges. For example, a new leader could come in with a new idea of the need and a new vision for the product, and the training developers would have to “start over.”

Implementation

POI integration. For 6/7 products (87%), it was reported that they were not systematically incorporated into the course POIs after development. It was also reported that the products were not monitored or tracked after development to ensure they were actually being used in the classroom. In fact, there was an uncertainty as to whether instructors were using the products or were even aware that they existed. Despite lack of POI integration, some of the products were used by instructors who saw the benefit of their use and passed this information on to other instructors.

Instructor training. For 4/7 products (57%), instructor training on how to use the products was very minimal. An example of instructor training included a brief explanation or quick run through of the product with instructors. Level 2 IMI products, however, are generally self-explanatory as they often involve a student opening an eLearning application from their laptop and continuing self-paced until completion.

Product use. 100% of the products were reported as being used in a variety of ways to support the learning objectives. Related to the POI integration statistic above (87% not systematically incorporated into the course POI), instructors were almost obliged to use the product in different ways since the POI did not provide guidance. It would depend on the instructor’s experience with the product and the need of the students as to whether it was used as self-directed training, study time, preview or review of course material or used in-class or as homework. Specially, 6/7 products (86%) were leveraged as a preview or review of course material to support familiarization or refresher training.

Evaluation and sustainment

Evaluation/learning outcomes. For 6/7 products (86%), it was reported that no formal evaluation was conducted to determine the effectiveness or effects of using the product on

student learning. Without data on those formal measures, it is challenging to validate the effects of the products on student performance. However, for 5/7 products (71%), subjective data were gathered informally from students and instructors (e.g., products reinforced student understanding and retention, promoted self-paced learning, appealed to students with different learning preferences, and increased engagement and student ownership of learning).

Product update/continuous improvement. For 4/7 products (57%), the need for revisions fell into two categories: (1) errors resulting from technological glitches or resulting from content inaccuracy, and (2) new materials development or material updates. For 5/7 products (71%), there were practical challenges for updating the products (e.g., required collecting the products to load the new version and redistribute), technical issues (e.g., operating system upgrades), and other challenges (e.g., asset continuity, manpower, and contract management). It was reported for 4/7 products (57%) that there were means to collect and monitor user feedback to ensure products remained accurate and up-to-date. This would allow for timely and continual improvements.

Across the product development cycle. A common theme emerged across all ADDIE phases regarding manpower and resources for Level 2 IMI products. Resource constraints which included cost, time, expertise, and manpower had an impact on the type of product developed for the course. This theme was reported for 5/7 products (71%).

Level 3 IMI Product Themes

Level 3 IMI. These products require the user to recall more complex information than level 1 or 2 IMI products. Users have even more control over the lesson content or scenario than a Level 2 IMI through peripherals such as light pen, touch screen, track ball, or mouse. Data were collected for nine level 3 IMI products.

Analysis, design, and development

SME-related. For 7/9 products (78%), it was reported that there was adequate SME support throughout design and development. However, it was noted in four responses that there were challenges in gaining access to the right SMEs or that there was a lack of consistency in SMEs or SME input. For example, there were difficulties in keeping the same SMEs involved throughout the process.

Front-end analysis. For 8/9 products (89%), it was reported that there was a reason for product development; however, the reasons varied. For three products, the reason was associated with a leadership request. For two products, the reason was to address a training gap between the “walk” and “run” phases, i.e. providing opportunity to practice before live exercises. For two products, the reason was aligned with the ALM tenet of rendering the training more engaging to students. For one product, the reason was to address logistical limitations of the training (allow all students to view the same content at once).

For 6/9 products (67%), it was reported that a front-end analysis was conducted; however, the methods for conducting the analysis varied. For some products, the course was

observed by the training developer. For other products, the training developers gathered input from instructors and students. In some cases, a critical task analysis was performed.

For 6/9 products (67%), it was reported that collaboration and consensus among stakeholders regarding the need for and requirements of the training product was important and if lacking led to issues including vague requirements, a failure to explain the need for the product to the developers, difficulty with technology tool selection, allowing the customer to dictate what should be developed, lack of clarity regarding product ownership, and lack of input from technology team early on in the design process.

Technology specifications. For 5/9 products (56%), the products were used on multiple devices or browsers. For two of the products, frustration resulted from a lack of consistency in tool navigation and graphics display across multiple devices or browsers. Responses for two products indicated a desire to use a device-agnostic approach to the development of the training product, thus reducing this type of frustration.

Implementation

POI integration. For 5/9 products (56%), it was reported that they were not formally incorporated into the course POIs after development. Despite a lack of POI integration, it was reported that these products were being used by instructors on their own initiative to support course learning objectives.

Instructor training. For 6/9 products (67%), no formal instructor training was provided. In some cases, instructors were given opportunities to familiarize themselves with the product before classroom use.

Product use. For 5/9 products (56%), it was reported that the products were used in a variety of ways to support the learning objectives. Product use depended on the instructors' experiences with the product and the need of the students (e.g., whether it was used as preview (prerequisite) training, classroom instruction, homework assignment, refresher training, or as a check on learning/assessment). Three of the products were used for both individual and group activities.

Instructor use. For 5/9 products (56%), the responses reflected the effects of using the products on instructors' workloads. For two products, reasons for increases in instructors' workloads included the use of the product itself, the instructor's lack of familiarity with the product, and the added administrative requirements associated with the product. For one product, instructor workload increased at the onset but gradually decreased over time. For one product, instructor workload decreased because students asked fewer questions. For one product, there was no difference in instructor workload as a result of using the product.

Evaluation and sustainment

Evaluation/learning outcomes. For 100% of the products, it was reported that no formal evaluation occurred to determine the effectiveness or effects of using the product on student learning. However, for 6/9 products (67%), the results from subjective data indicated that there was a positive influence on student learning and performance. For example, for 5/9 products (56%), it was reported that the product provided a good visual of the equipment, allowing students to retain information and perform well on the live equipment.

For 8/9 products (89%), students received feedback on their performance in the tool via instructor critiques or assessment results produced by the tool in an After Action Review (AAR) format.

Product update/continuous improvement. For 6/9 products (67%), the results reflected constraints for product updates. Products that were developed in-house faced time constraints while products developed by contractors faced issues with contracts and funding, access to support personnel, and access to source codes.

For 5/9 products (56%), it was reported that the selection of software used to build the technology product was the main factor for updates or revisions post-development.

Across the product development cycle. A common theme emerged across all ADDIE phases regarding manpower and resources for Level 3 IMI products. For 5/9 products (56%), it was reported that there was a need (or preference) for in-house development and sustainment yet lack of manpower and resources to support that.

Level 4 IMI Product Themes

Level 4 IMI. These products involve a more in-depth recall of larger amounts of information as compared with the other IMI levels. The user has an increased level of control over the lesson material and scenarios. Every possible subtask is analyzed and presented with full, on-screen interaction, similar to the approach used in aircraft simulator technology. Data were collected for five level 4 IMI products.

Analysis, design, and development

SME-related. For 3/5 products (60%), it was reported that accessing the “right” SMEs and having the ability to leverage the same, small set of SMEs was vital to product development cycle. A “right” SME reflects individuals with relevant content expertise and familiarity with all details (especially with terrain, formation, movement, etc.) Two of these three products reported challenges with SMEs, notably that high-performing SMEs were sought after and obtained by other organizations.

Implementation

POI integration. Eighty percent of the products (4/5) were used by instructors as optional tools during a course to reinforce student learning and engagement. For three of the products, there was a lack of adequate training/communication with instructors on how to integrate the tool into the course POIs.

Instructor training. For 3/5 products (60%), it was reported that instructor training was required; however, the amount of training varied. For one product, a significant amount of training was needed in order to show instructors how to bring up scenarios and inject faults. For two of the products, there was a small learning curve as the products were more intuitive in nature. It is important to point out that simulators resemble the equipment; therefore, it may be inferred that instructors needed minimal training. Yet, some of the products required data to be pulled from simulators or required instructors to use monitoring stations for performance observation. Instructors were trained informally on these functions by other instructors.

Product use. Eighty percent of the products (4/5) were reported as versatile, allowing instructors to customize and adapt scenarios to meet different learning objectives and informally assess student performance. Many of these products were also available for student use at their home station.

Eighty percent of the products (4/5) were used by instructors as the “walk” phase of the Army’s crawl, walk, run training method so students were able to practice before using the actual equipment and during class “down time”. For example, the products were used to get struggling students up to speed with additional practice or to provide students with additional practice while they were waiting to train on the live equipment. Products were also used as reach-back (sustainment) training.

Instructor use. Eighty percent of the products (4/5) provided minimal feedback to students on their performance; therefore, instructors had to monitor students using the product and provide feedback and guidance.

For 3/5 products (60%), there was little to no impact on instructor workload. In some cases, the impact on the instructor workload was a zero-sum gain; it was reported as the same amount of work, just different.

Evaluation and Sustainment

Evaluation/learning outcomes. For 4/5 products (80%), it was reported that no objective or hard data existed. However, instructors and students reported that the use of the tools had a positive impact on student performance. Instructors indicated that they could see the difference with live equipment performance based on use of the products.

For 4/5 products (80%), it was reported that the accuracy of simulation, as it resembles live equipment, is very important to achieving targeted learning outcomes.

It was reported for 3/5 products (80%) that the tools impacted ROI by reducing training time on the live equipment. Some of the examples of this ROI included a reduction of wear and tear on the live equipment as well as reduction in fuel costs as it pertained to time needed in aircrafts (since students were already prepared and did not need to train on fundamental tasks).

Product update/continuous improvement. For 4/5 products (80%), the need to maintain the product fell mostly into two categories: software upgrades and reliability issues such as bugs causing system to malfunction or shut down. The results for three of the products indicated the importance of documenting bugs or glitches, as this assists with the maintenance process.

Across the product development cycle. A common theme emerged across all ADDIE phases regarding manpower and resources for Level 4 IMI products. For 3/5 products (60%), it was reported that the lack of funding or an ongoing maintenance contract was found to be a barrier both in development and sustainment.