Adapting Gunnery Training Using the Experience API

Rodney Long
United States Army Research Laboratory
Human Research and Engineering Directorate
Simulation and Training Technology Center
Orlando, FL
rodney.a.long3.civ@mail.mil

Michael Hruska, Ashley Medford
Problem Solutions
Johnstown, PA
mike@problemsolutions.net,
amedford@problemsolutions.net

Jennifer Murphy, Carolyn Newton
Quantum Improvements Consulting
Orlando, FL
jennifer.murphy@quantumimprovements.net,
carolyn@quantumimprovements.net

Tara Kilcullen, Robert L. Harvey Jr.
Raydon Corporation
Port Orange, FL
tkilcullen@raydon.com,
bharvey@raydon.com

ABSTRACT

The Army's Training and Doctrine Command (TRADOC) has described plans for modernizing Army training in documents such as the Army Learning Model (ALM, TRADOC PAM 525-8-2). The ALM calls for increasing the personalization of the soldier learning process so that training is tailored to the individual soldier throughout his/her career. To accomplish this goal, a persistent representation of soldier performance across a variety of technology-based training systems is required. Currently, performance data throughout the live, virtual, constructive, and gaming (LVCG) spectrum is not maintained, nor is it used to adapt future training for soldiers or their units. However, advances in data interoperability have recently made development of complex student models using this performance data a possibility. The Experience API (xAPI) is one such innovation. As part of our research, we have used the xAPI to capture interoperable performance data for unstabilized gunnery simulators. Using this performance data, we have developed an adaptive training curriculum in which crew training is adapted based on prior individual performance on a gunnery simulator. This paper describes the development of interoperable performance data for unstabilized gunnery simulators using the xAPI specification as well as the findings of an experiment to demonstrate gains in learning and training efficiency. The results can be used to inform the Army in its training modernization goals, as well as the simulation-based training community as a whole.

ABOUT THE AUTHORS

Rodney Long is a Science and Technology Manager at the Army Research Laboratory, Human Research and Engineering Directorate, Simulation and Training Technology Center (STTC) in Orlando, Florida. He is currently conducting research in adaptive training technologies, including intelligent tutoring systems, architectures, authoring tools, etc. Mr. Long has a wide range of simulation and training experience that spans 27 years in the Department of Defense (DoD) and has a Bachelor's Degree in Computer Engineering from the University of South Carolina and Master's degree in Industrial Engineering from the University of Central Florida.

Michael Hruska is a technologist with experiences spanning across standards, emerging technologies, learning, and science. He is a former researcher at the National Institute of Standards and Technology in Gaithersburg, Maryland. He is currently the President / Chief Executive Officer of Problem Solutions, and provides learning technology solutions to government, commercial, and nonprofit organizations. His team has been supporting efforts for the last 6 years at the Advanced Distributed Learning (ADL) Initiative on the future of a Training and Learning Architecture (TLA) and the Experience Application Programming Interface. He holds a Bachelor of Science from the University of Pittsburgh and is a member of the e-Learning Guild, American Society of Training and Development (ASTD) and the National Defense Industrial Association (NDIA).

Ashley Medford is the Director of Government Services at Problem Solutions. She is an experienced program manager, specializing in the development and use of immersive technologies for Federal and Government education, training, analysis, and collaboration. Throughout her career, Ms. Medford has led various immersive learning technology programs and projects for major Government and Defense clients, including the Air Force Research Laboratory, United States (U.S.) Naval Air Systems Command, Army Research Laboratory, National Aeronautics and Space Administration (NASA), Office of Naval Research, U.S. Special Operations Command, and U.S. Central Command. Ms. Medford has provided consultation and program management for modeling, simulation, and virtual training and collaboration environments. She is also a member of the e-Learning Guild, the American Society of Training and Development (ASTD), the Project Management Institute (PMI), and the National Defense and Industrial Association (NDIA).

Jennifer Murphy is the Chief Executive Officer of Quantum Improvements Consulting, LLC. She has over 10 years of military selection and training research experience, with an emphasis on leveraging innovative technologies for improving training in a measurably effective way. Upon completion of her Doctorate of Philosophy (Ph.D.) from the University of Georgia in 2004, Dr. Murphy took a position as a Research Psychologist at the United States Army Research Institute for the Behavioral and Social Sciences (ARI). Her research focused on the development of technology-based selection and training measures for cognitive and perceptual skills. Dr. Murphy served as Director of Defense Solutions at Design Interactive, Inc., where she managed a portfolio of training and performance support efforts incorporating cutting edge technology into training solutions for defense clients. Her research has been featured in *The New York Times*, the Pentagon Channel, *Soldier* Magazine, and *Signal* Magazine.

Carolyn Newton is a training consultant at Quantum Improvements Consulting, LLC. Carolyn earned her Bachelor of Science in Human Factors from Embry-Riddle Aeronautical University last December. Her research has focused on human performance in extreme environments, including participation in a two-week simulation at the Mars Desert Research Station. She has also been involved in observing mission operations at the National Aeronautics and Space Administration (NASA) Extreme Environment Mission Operations (NEEMO) project. Last summer, she completed an internship at the Space and Naval Warfare Systems Command (SPAWAR) in San Diego, where she collaborated on 6 research projects supporting the efficiency of logistics personnel in the military. She has presented at several regional and national conferences, including the annual meetings of the Southeastern Psychological Association and the Human Factors and Ergonomics Society.

Tara Kilcullen is the Director of Training Product Development at Raydon Corporation. Ms. Kilcullen has over 12 years of experience leading and managing cross-functional teams in the design and development of training simulation systems with a focus on training technologies and development as well as data collection and analyses for Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2014 both military and commercial systems. She has helped to implement and drive process improvements both within her organization and other organizations at Raydon. With these improvements came better metrics through enhanced data collection and analysis methods which specifically allowed Training Product Development to gain numerous development efficiencies revolving around project planning, organization, execution, and quality. She holds several Bachelor of Science and Associate of Science degrees from University of Pittsburgh and Full Sail University.

Robert Harvey is the Director of Applied Training at Raydon Corporation. Mr. Harvey has over 20 years of experience developing training simulation systems with a primary focus on training effectiveness and performance data collection and analysis. His expertise and knowledge of training design, development and analysis enables him to guide the design, development, and application of technologies as they are applied to training courseware and training system development, to include a wide array of military and commercial training applications. He is also is one Raydon's primary architects and researchers specializing in the collection and analysis of simulation and training performance data. He holds a Bachelor of Science Degree in Aeronautical Engineering from Embry-Riddle Aeronautical University.

Adapting Gunnery Training Using the Experience API

Rodney Long
United States Army Research Laboratory
Human Research and Engineering Directorate
Simulation and Training Technology Center
Orlando, FL
rodney.a.long3.civ@mail.mil

Michael Hruska, Ashley L. Medford
Problem Solutions
Johnstown, PA
mike@problemsolutions.net
amedford@problemsolutions.net

Jennifer S. Murphy, Carolyn Newton
Quantum Improvements Consulting
Orlando, FL
jennifer.murphy@quantumimprovements.net,
carolyn@quantumimprovements.net

Tara Kilcullen, Robert L. Harvey Jr.
Raydon Corporation
Port Orange, FL
tkilcullen@raydon.com,
bharvey@raydon.com

INTRODUCTION

As the U.S. Army works toward its goals of training modernization, it faces unprecedented training challenges. It must prepare soldiers for future conflicts in an increasingly complex operational environment. At the same time, constraints in training budgets mean the Army must learn to do more with less; training effectiveness must be maximized to provide soldiers with valuable learning experiences while keeping costs down. The Army is investigating the use of adaptive training techniques as one means of increasing training efficiency. Research suggests adaptive training technology can show benefits above traditional training paradigms (Durlach & Ray, 2011). Often, adaptive training results in improved learning of the material presented, or comparable learning in a shorter amount of time.

While research into adaptive training is promising, the literature is far from conclusive; often experiments comparing adaptive and non-adaptive training technologies find no difference between the two approaches and sometimes, adaptive approaches are found to be less effective. It is rare to find evidence of a direct comparison of adaptive and non-adaptive approaches to training technology (Durlach & Ray, 2011). Such comparisons involve the development of parallel versions of training, which is costly and not often done for research purposes. A more relevant question from the Army's perspective is not whether adaptive training is effective, but whether it provides enough benefit to justify the expense of implementing these systems. In this paper, we describe research to address the question of whether adaptive training technology can provide effective, efficient training compared to traditional training in a gunnery use case.

Adaptive training is one aspect of the Army's training modernization plans, but our research also addresses the broader goal of developing persistent representations of trainee performance that could be leveraged across training platforms throughout the Warfighter's career. In the *Army Learning Concept for 2015* (Dept. of the Army, 2011), Army Training and Doctrine Command (TRADOC) describes the need for an online career-tracking tool to manage individual performance data and provide soldiers a way of visualizing progress towards their lifelong learning objectives. In order to meet this goal, however, data must be collected and shared across various technology platforms. To date, this requirement has been a challenge to achieve. However, advances in data analytics have enabled the cross-platform sharing of performance data required to assess and track a soldier's lifelong learning trajectory.

The Experience Application Programming Interface (xAPI) offers one mechanism to represent performance data in an interoperable way. Developed by the Advanced Distributed Learning (ADL) Co-Lab, the xAPI provides an interoperable means to describe and track individual and group learning experiences across multiple systems within a learning ecosystem (Advanced Distributed Learning, 2014). This learning and performance data is centrally stored within a database known as a Learning Record Store (LRS). The data stored within an LRS may be retrieved for summative analysis. With the ability to measure and analyze performance across simulators, the xAPI enables the execution of efficient training effectiveness evaluations and in turn, identification of Return on investment (ROI) for costly, adaptive training systems. However, many systems, such as simulators, do not currently incorporate the xAPI specification. To address this issue, the Army Research Laboratory developed Pipeline, a simple wraparound that permits a system to generate and consume xAPI activity statements. Pipeline is a Microsoft.NET dynamic link library (DLL) that provides simulator vendors with a simplified software interface to track performance data using the xAPI format. It reduces the complexity for software teams that are implementing the xAPI into their simulation products, by abstracting many of the implementation details, such as transport and security. More importantly, the ability for multiple systems to quickly produce and consume the xAPI enables data interoperability within a learning ecosystem.

The Army Research Laboratory is currently investigating the extent to which xAPI data can be used in an adaptive training context. Specifically, there is interest in whether individual performance data shared across multiple simulators can be used to drive an adaptive curriculum that maximizes the effectiveness of individual and team training. In this effort, performance data represented in xAPI statements from an individual gunnery trainer were used to drive the adaptive training curriculum for a gunnery crew, effectively basing the team's course of instruction on the prior performance of an individual within the team. This cross-simulator adaptation was facilitated by the use of xAPI data and served as a use case for how this specification can be used to share performance data across multiple training instantiations.

Our research focused on demonstrating the improved efficiency of the adaptive training curriculum. We accomplished this by comparing crew training between a group of trainees that received the adaptive version of the gunnery curriculum and a group that received a standard Army gunnery table progression. We anticipated three potential effects. First, we predicted that the adaptive group would outperform the standard group. While the Army typically trains gunnery to standard, often trainees do not have sufficient time to engage in every required exercise before they exhaust their training time. Using an adaptive curriculum would enable teams to progress more quickly through the curriculum, thus giving them more time to work on problem areas for the individual gunner. This would result in a higher final qualification score. We also predicted that the adaptive group would complete the total curriculum more quickly than the standard group. Finally, the adaptive group should complete the curriculum using fewer scenarios than the standard group. While the time to complete and number of scenarios are inherently related measures, they provide slightly different representations of training efficiency. Below, we describe the simulator systems used in this research, followed by a discussion of our experimental methods and results.

ADAPTIVE SIMULATOR SYSTEMS

Raydon Corporation's Unstabilized Gunnery Trainer – Individual (UGT-I) (Figure 1) is a virtual simulation training system that trains and evaluates the operator of the weapon turret on unstabilized vehicle platforms, such as variants of High Mobility Multipurpose Wheeled Vehicles (HMMWVs) or Mine-Resistant Ambush Protected (MRAP) vehicles. The UGT-I provides the gunner with a fully functional, simulated .50 caliber M2 Browning machine gun, turret traversing controls, a simulated heavy weapon thermal sight (HWTS), and a universal pintle mount with an attached Traverse and Elevation (T&E) mechanism. The UGT-I places the gunner into scenarios with a synthetic driver and commander to execute gunnery engagements where the gunner attempts to destroy threat targets. The gunner's performance is assessed by measuring engagement times and proper responses to fire commands in accordance with FM 3-20.21 Heavy Brigade Combat Team (HBCT) Gunnery.

Figure 1. Unstabilized Gunnery Trainer - Individual (UGT-I)

The Unstabilized Gunnery Trainer – Crew (UGT-C) (Figure 2) is a virtual simulation training system that trains and evaluates unstabilized gunnery performed by the crew of unstabilized vehicle platforms. The UGT-C provides simulated operating positions for the vehicle driver, commander and gunner, as well as an instructor/operator station (IOS). The crew's performance is assessed by measuring engagement times and proper responses to fire commands IAW FM 3-20.21 Heavy Brigade Combat Team (HBCT) Gunnery. The vehicle gunner station from the UGT-I is integrated and used with the driver and commander positions and has the same capabilities as the UGT-I. All of the crew members, and the instructor, communicate using tactical vehicle headsets over a vehicle intercom system.

The IOS allows the instructor to register the crew to be trained, initialize the training session, select and monitor the training exercise, and to perform an After Action Review (AAR) with the crew using a scoring results page and an exercise playback capability. The instructor also uses the IOS to enter any crew penalties to the crew score, if an infraction is observed.

Figure 2. Unstabilized Gunner Trainer - Crew (UGT-C)

Adaptive Training Curriculum

The UGT-I training curriculum incorporates exercises that present varying arrays of firing conditions that include:

- Firing Vehicle Posture (offensive, defensive, Traffic Control Point (TCP))
- Target Counts (single or multiple)
- Target Ranges (short, medium, long)
- Target Movement (stationary, moving, mixed)
- Visibility (day, night)

Each completed exercise is evaluated and the performance in each of these conditions is used to update a Gunnery Table task table (Figure 3). Once the required level of task performance is met, the gunnery is allowed to fire a Gate-to-Live Fire (GTLF) exercise which simulates a Gunnery Table VI qualification exercise.

Task Table

		Table III Proficiency	Table IV Basic	Table V Practice	Table VI Qual
Task 0 VC Single/Sta		74 7 / 10	74 7 / 10	74 7 / 10	74 7 / 10
Task 1 VC Single/Sta		74 7 / 10	74 7 / 10	74 7 / 10	74 7 / 10
Task 2 Single/Sta		65 3 / 10	65 3 / 10	65 3 / 10	65 3 / 10
Task 3 Single/Mov		65 3 / 10	65 3 / 10	65 3 / 10	65 3 / 10
Task 4 Single/Sta (Degraded)		73 7 / 10	73 7 / 10	73 7 / 10	73 7 / 10
Task 5 Mult/Mix (Degraded)		75 4 / 10	75 4 / 10	75 4 / 10	75 4 / 10
Task 6 Mult/Sta					
Task 7 Mult/Sta					
Task 8 Mult/Mix					
Task 9 Mult/Mov					

Task Table

		Table III Proficiency	Table IV Basic	Table V Practice	Table VI Qual
Task 0 VC Single/Sta		85 8 / 10	85 8 / 10	85 8 / 10	85 8 / 10
Task 1 VC Single/Sta		78 8 / 10	78 8 / 10	80 8 / 10	80 8 / 10
Task 2 Single/Sta		85 8 / 10	85 8 / 10	85 8 / 10	85 8 / 10
Task 3 Single/Mov		85 8 / 10	85 8 / 10	85 8 / 10	85 8 / 10
Task 4 Single/Sta (Degraded)		81 8 / 10	81 8 / 10	81 8 / 10	81 8 / 10
Task 5 Mult/Mix (Degraded)		83 7 / 10	83 7 / 10	83 7 / 10	83 7 / 10
Task 6 Mult/Sta		83 7 / 10	83 7 / 10	83 7 / 10	83 7 / 10
Task 7 Mult/Sta		78 8 / 10	78 8 / 10	78 8 / 10	78 8 / 10
Task 8 Mult/Mix		78 8 / 10	78 8 / 10	78 8 / 10	78 8 / 10
Task 9 Mult/Mov		80 8 / 10	80 8 / 10	80 8 / 10	80 8 / 10

Figure 3. UGT-I Skill Progression Using Gunnery Table Task Tables

The curriculum provided by the UGT-C (Figure 4) progresses the crew through a series of 20 Pre-Live Fire (PLF) exercises that are designed to train and assess gunner and commander firing performance, as well as crew coordination. After the crew progresses through the PLF exercises, they are then presented a series of Gunnery Table Practice exercises for Tables II through V. After completing the library of Gunnery Table Practice exercises, the crew completes the training program by running a GTLF exercise, simulating a Gunnery Table VI, in order to determine the crew’s qualification status.

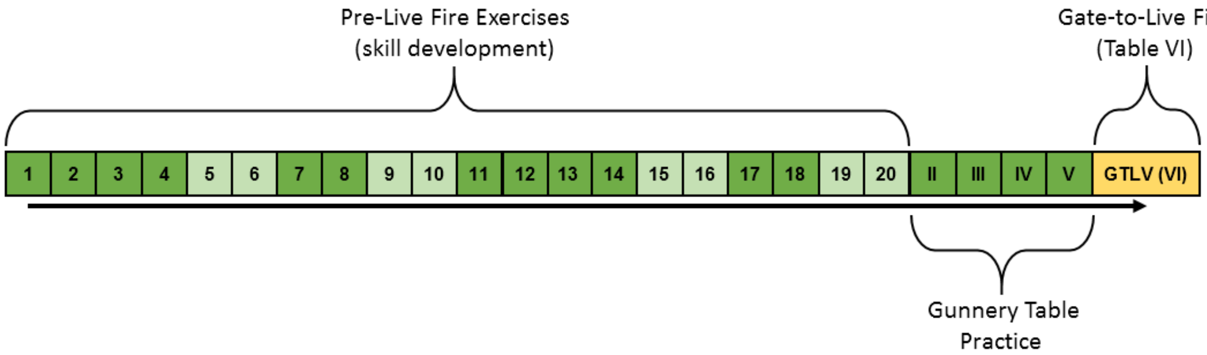

Figure 4. UGT-C Crew Training Program

The adaptive crew training capability was developed as an adjustment to the current crew training progression algorithm. The algorithm takes the individual training record for the crew gunner, assesses performance in each of the firing tasks and conditions, and applies "advanced credit" for those PLF exercises that apply to the passing conditions. The remaining PLF exercises are applied as the crew's new training progression through the crew curriculum. No matter how well the gunner performs, the adaptive program always requires the crew to pass a Gunnery Practice Table V prior to firing the GTLF. This ensures that any issues that may arise from integrating the gunner to the rest of the crew are assessed and addressed prior to running the qualification exercise. Figure 5 demonstrates an example of how the adaptive crew training program responds to a gunner's individual performance record.

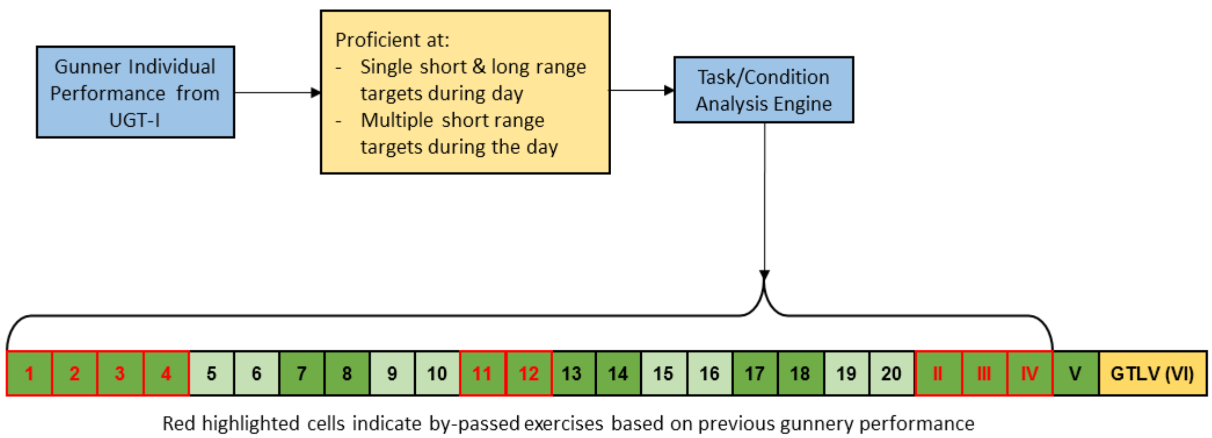

Figure 5. Example Application of Adaptive Crew Training Program

Performance Assessment

Gunnery performance is measured using the gunnery engagement evaluation criteria specified in the HBCT gunnery manual (FM 3-20.21). Each engagement fired is assigned a point-based score between 0 and 100 points. The points are calculated from a set of tables that use a combination of the firing vehicle's postures, the target type, target movement, target range, and the time that the target is destroyed. These points are then totaled to determine if the engagement is qualified/passed by scoring 70 or more points. If one or more targets in the engagement are measured with a score of less than 70 points, the engagement is assessed as unqualified. Further point reductions may be applied if the gunner fails to respond to fire commands correctly during the execution of the firing engagement.

At the conclusion of a UGT-I or UGT-C, the exercise is assigned a pass/fail status. A pass is given if 70% or more of the available points are earned and 70% or more of the presented engagements are qualified. If either of these conditions are not met, the exercise is given a fail status. For any GTLF exercise completed on the UGT-I or the UGT-C, the exercise is assigned a qualification status using the engagement points total and the number of qualified engagements. Table 1 summarizes the qualification status ratings for GTLF exercises.

Table 1. Gate-to-Live Fire Qualification Ratings

Qualification Rating	Score and Engagement Conditions
Distinguished	The crew obtains a score of 900 to 1,000 points with 70 or more points on 9 of the 10 tasks.
Superior	The crew obtains a minimum score of 800 points with 70 or more points on 8 of the 10 tasks.
Qualified	The crew obtains a minimum score of 700 points with 70 or more points on 7 out of 10 tasks.
Unqualified	The crew obtains a combined score of 699 or fewer points, or 69 or fewer points on 4 or more of the 10 tasks.

TRAINING EFFECTIVENESS EVALUATION

To determine the extent to which the adaptive crew curriculum provided improved training effectiveness, an experiment was conducted. In this experiment, crew gunnery performance with the adaptive curriculum was compared with performance in a "standard" curriculum that reflected the Army's typical crew gunnery training procedures. We predicted that participants in the adaptive condition would show higher qualification scores than the standard condition. That is, we predicted an increase in training effectiveness using the adaptive curriculum. In addition, we predicted that participants in the adaptive group would complete the training in less time and using fewer scenarios. This finding would indicate the adaptive curriculum was not only more effective, but also more efficient.

Participants

The participants in this study consisted of 28 undergraduate students (25 men, 2 women) in the Reserve Officer Training Corps (ROTC) at Embry-Riddle Aeronautical University (ERAU). Average age of the participants was 19.5 years (SD = 1.13). Participants were briefed on the purposes of the experiment and provided their informed consent. The participants were compensated through funding given to the head of their unit that would be used toward unit activities. Upon their arrival, half of the participants were assigned to the adaptive condition and half were assigned to the standard condition. Due to missing data, two participants from the standard condition were excluded from analysis.

Procedure

Data collection was carried out in the manufacturing wing of the Raydon Corporation's facility in Port Orange, Florida. Testing took place over the course of two days, up to three hours each day, for each participant. On the first day, all participants completed UGT-I training with the assistance of one instructor. The second training day immediately followed the first and focused on completing the UGT-C curriculum. On this day, half of the participants completed an adaptive crew curriculum, and half completed a standard, non-adaptive training curriculum. Two Raydon employees with extensive gunnery simulation experience trained alongside the participant, one acting as a simulated crew member and the other acting as instructor. To maintain consistency across participants, instructors and crew members were chosen for their expertise in the training and were provided instruction regarding the level of feedback to provide each participant. Each participant worked with the same instructor across both training days. Participants were given two hours and ten minutes to complete the crew exercises. After this time, they completed the GTLF scenario, which served as a qualification exercise. Once they received a qualification score, they were debriefed and thanked for their participation.

Results

Overall performance was measured in three ways: qualification score; time to completion; and the number of scenarios. Qualification score is calculated in the GTLF scenario during crew training. After completing GTLF, each participant was given a numerical score from 0-1000. This rating is based on points gained or lost based on performance in variables, such as weapon handling; situation awareness; and accuracy of vocal commands. Time to completion was measured in minutes, and accounted for the time to run through all scenarios including GTLF. Average number of scenarios to completion was also calculated. Means for all three dependent measures were compared between adaptive and standard conditions using independent sample t-tests. Due to a low sample size, the researchers were unable to perform a more detailed analysis of these performance measures.

UGT-I Performance

Although the comparisons of interest took place in the UGT-C, we compared participants' performance between groups in the UGT-I to ensure that no pre-existing differences existed between the groups. The qualification scores in the UGT-I did not vary significantly between the cadets in the adaptive group (M = 843; SD = 72.36) and those in the standard group (M = 888; SD = 57.38), $t(22) = 1.71$; $p > .05$. The average score for each group was in the "Superior" range, indicating that participants generally performed very well in this training. No differences were found in average time to completion between the adaptive (M=99.98; SD = 22.40) and standard groups (M = 86.00; SD = 16.70), $t\,(22) = 1.76$; $p > .05$. Finally, the number of scenarios required to complete the individual training did not differ between the adaptive (M = 18.5; SD = 4.60) and standard groups (M = 17.3; SD = 4.90), $t\,(24) = .65$; $p > .05$. While the lack of differences between these groups in the UGT-I was not surprising, it was important to demonstrate that any differences in crew performance were due to our training curriculum manipulation.

UGT-C Performance

Contrary to our predictions, the average qualification score of the standard group (M = 973; SD = 16.03) was significantly higher than that of the adaptive group (M = 945; SD = 44.48), $t\,(17) = 1.98$; $p < .05$. It is important to note, however, that average qualification scores in both groups are very high, with all but three participants in the adaptive group receiving a "distinguished" rating (see Figure 6).

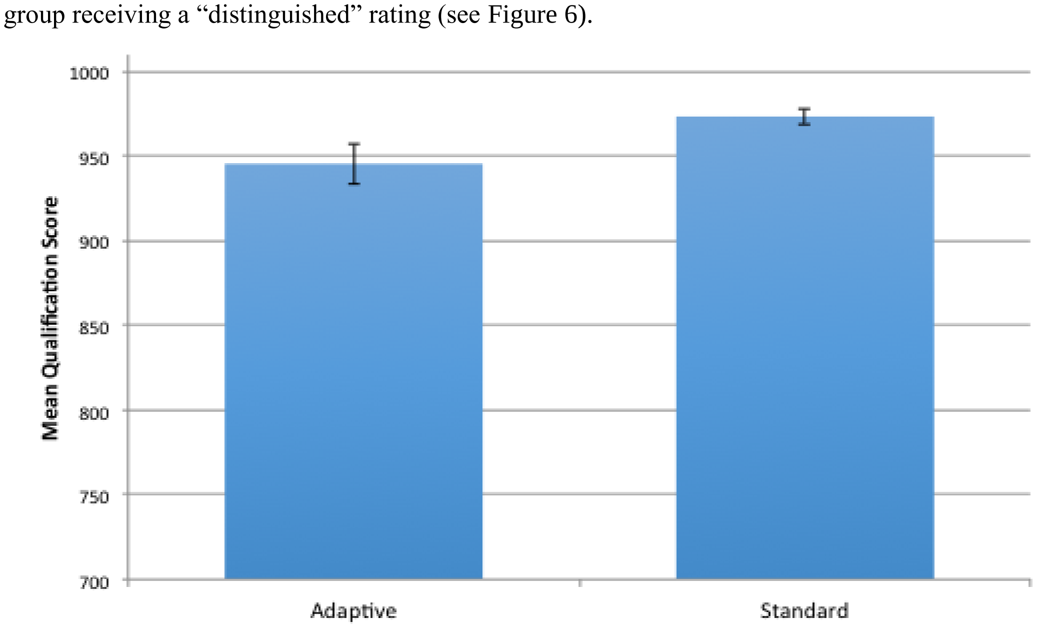

Figure 6. Average UGT-C qualification scores

The adaptive group (M = 77.07; SD = 32.60) required significantly less time (in minutes) to complete the training than the standard group (M = 131.15; SD = 13.55), $t\,(18) = 5.14$; $p < .05$. Similarly, the adaptive (M = 7.28; SD = 3.83) group required significantly fewer scenarios than the standard (M = 16.90; SD = .94) group ($t\,(14) = 9.05$; $p < .05$). These differences are illustrated in Figure 7 and Figure 8.

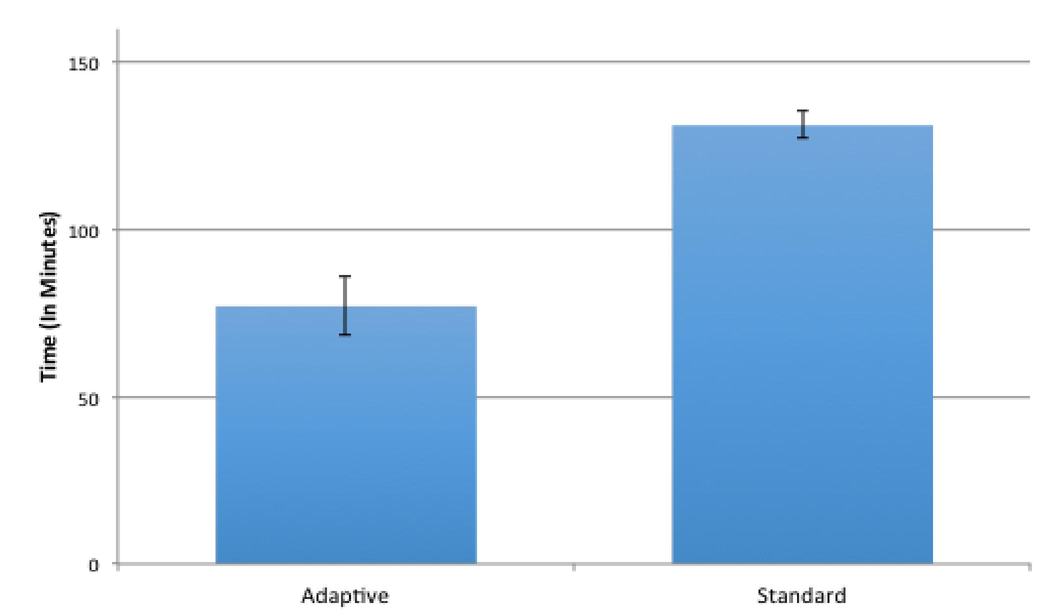

Figure 7. Average time to completion during UGT-C training

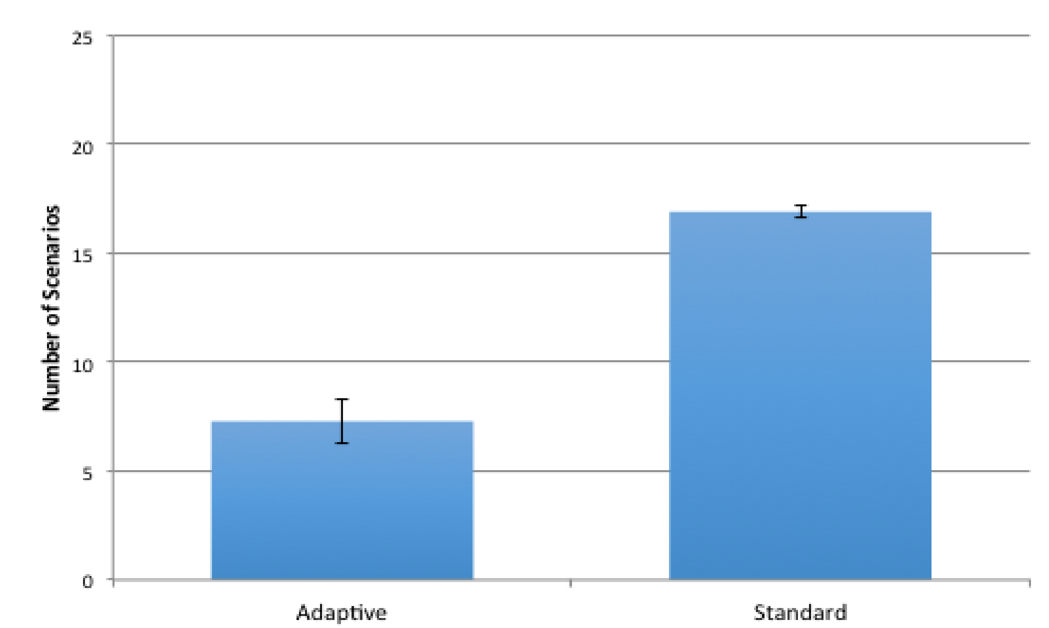

Figure 8. Average number of UGT-C scenarios completed.

The findings of this research indicate that while participants who received the full standard UGT-C curriculum had significantly higher qualification scores, the participants in the adaptive group completed the training with less time in training and fewer scenarios. It is important to note that while the differences between group qualification scores is statistically significant, both groups performed extremely well. Considering the high scores in both groups, our findings suggest that using an adaptive curriculum in the UGT-C results in substantial savings in training time while maintaining excellent training outcomes. In fact, participants completed the crew training in the adaptive condition with an average of 40% less time and nearly 60% fewer scenarios. These results make a strong case for the inclusion of adaptive training as part of military personnel development.

FUTURE RESEARCH

Under this effort, we compared performance between crews that received an adaptive UGT-C curriculum based on the gunner's performance in the UGT-I and crews that received a standard curriculum without adaptive elements. Our research suggests that using an adaptive training curriculum led to a significant reduction in the amount of time to train with comparable final qualification scores. While these data are promising, the applicability of these results is limited in that the crew training was adapted based on the performance of the gunner, not the entire crew. To demonstrate the full potential savings in time and cost of an adaptive curriculum, a fully adaptive crew curriculum will be implemented and validated. In addition, to further the applicability of our findings to the larger Army, a validation study will be conducted with Active Army soldiers.

REFERENCES

Advanced Distributed Learning (2014). Training and Learning Architecture (TLA): Experience API (xAPI). Retrieved from http://www.adlnet.gov/tla/experience-api.

Durlach, P. J. & Ray, J. M. (2011). Designing adaptive instructional environments. Technical Report 1297, U.S. Army Research Institute for the Behavioral and Social Sciences: Arlington, VA.

Erwin, S. I. (2012). Budget costs, fuel costs could spur military spending on virtual training. National Defense Magazine. http://www.nationaldefensemagazine.org/archive/2012/December/Pages/BudgetCuts,FuelsCostsCouldSpurMilitarySpendingonVirtualTraining.aspx

Government Accountability Office (2013). Army and Marine Corps training: better performance and cost data needed to more fully assess simulation-based efforts. GAO 13-698.

Hruska, M., Kilcullen, T., Amburn, C., Long, R., & Poeppelman, T. (December, 2014). Experience API and team evaluation: evolving interoperable performance assessment. Proceedings of the Interservice/Industry Training, Simulation, and Education (I/ITSEC) Conference, Orlando, FL.

Kirkpatrick, D. L. (1977). Evaluating training programs: evidence vs. proof. *Training & Development Journal*, *31(11)*,9-12.

Kozlowski, S. W. J., Toney, R. J., Mullins, M. E., Weissbein, D. A., Brown, K. G., & Bell, B. S. (2001). Developing adaptability: A theory for the design of integrated-embedded training systems. In E. Salas (Ed.), Advances in Human Performance and Cognitive Engineering Research, Vol. 1 (pp. 59-123). New York: JAI Press.

Murphy, J.S., Hruska, M., Goodwin, G.A., & Amburn, C.R. (March, 2015). Developing interoperable data for training effectiveness assessment in Army marksmanship training. Proceedings of the MODSIMWORLD Conference, Newport News, VA.

Oswalt, I., Cooley, T., Waite, W., Waite, E., Grodon, S., Severinghaus, R., & Lightner G. (2011). Calculating return on investment for U.S. department of defense modeling and simulation. Defense Acquisition University: Fort Belvoir, VA ADA539717.

Poeppelman, T. R., Hruska, M., Ayers, J., Long, R., Amburn, C., & Bink, M. (2013). Interoperable Performance Assessment using the Experience API. Proceedings of the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC), Orlando, FL.

Spain, R. D., Priest, H. A., & Murphy, J. S. (2012). Current trends in adaptive training with military applications: An introduction. *Military Psychology 24(2),* 87-95.

Training Industry (2013). Advanced Distributed Learning Initiative. Retrieved from www.trainingindustry.com: http://www.trainingindustry.com/taxonomy/a/advanced-distributed-learning-(adl)-initiative.aspx

U. S. Department of the Army (2011). The U.S. Army Learning Concept for 2015, TRADOC PAM 525-8-2. Fort Monroe, VA: U. S. Army Training and Doctrine Command.