Accelerated Learning Model for Increased Tactical Decision-Making Effectiveness in Unstructured Situations

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ABSTRACT

Warfighters today are required to train and learn quickly in ill-defined, and often stressful environments and situations. To accommodate rapid learning in such environments, the DoD Defense Science and Technology Advisory Group (DSTAG) created a research focus area concentration on developing methods for accelerating learning. Based on that focus, a multi-service team examined the problem space and recommended research be done to develop an accelerated learning model. Domain specific expertise is an area that develops over time as problem solving activities build in-depth understanding, mainly through the accumulation of experiences from which patterns or similarities can be recognized. The goal of this study is to determine if accelerated learning principles, derived from Cognitive Flexibility Theory and Cognitive Transformation Theory, can accelerate training for USMC personnel in tactical decision-making principles for uncertain situations. These learning principles were incorporated into a technology platform designed specifically for accelerated learning. The simulation technology used is a third-person virtual world simulation that places trainees in realistic situations that allow them to practice making decisions in a safe environment. The simulation provides iterative trial and error activity cycles where the participant must meet specific measurable goals within immersive decision-making scenarios, all under time compression.

Working with the USMC "The Basic School" (TBS) for Officer training in Quantico, VA, the research team trained TBS students in skills relevant to amphibious ship Well Deck operations, convoy operations and Expeditionary Advanced Base Operation (EABO) missions, using a new model of accelerated learning. The training scenarios were designed with a focus on planning and preparing for a mission in coordination with Naval Officers. The content focused on dealing with uncertainty while preserving mission goals. This paper reports on the training effectiveness of the accelerated learning approach, describes empirical findings, and discusses the analysis of the findings.

ABOUT THE AUTHORS

Lia DiBello - Chief Science Officer – ASCI- Inc. As Chief Scientist for ACSILabs, she is the innovator behind the FutureView™ Platform, which is recognized as a theoretical and methodological breakthrough in accelerated learning technologies. Dr. DiBello has also developed many innovative (non-verbal) methods of assessing skill and expertise. DiBello received her Ph.D. in cognitive psychology at CUNY Graduate School in New York. Since she started directing the research at ASCI she has been the recipient of 20 basic research funding awards from the National Science Foundation, NASA, National Academies of Science, and The Russell Sage Foundation. She has published numerous articles and is a frequent speaker on the topic of accelerated learning, Artificial Intelligence (AI), and learning under uncertainty.

Matt Fennell received his commission in the Marine Corps in 2001 and has served in multiple operational and training capacities. He is an experienced performance technologist with over twenty years in learning and development for the Department of Defense. In 2012 he implemented an end-to-end immersive training methodology fusing experiential, accelerated, and transformational learning into a cohesive methodology for training over 12,000 personnel per year. In 2015 he earned a Master of Science in Performance Engineering from Boise State University and is a doctoral candidate at Baylor University studying the effects of After-Action Review (AAR) training on personal agency in the Marine Corps.

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Sponsor Note and Acknowledgements – This work is performed under a Phase II Small Business Innovative Research grant from the Office of Naval Research, contract #N6833522C0650 under Program Officer Natalie Steinhauser. Special thanks go to the officers at The Basic School who designed the missions, especially Major Ryan Hart and Major Donald Burton, and to the ACSI Labs development team who worked on the simulation; Chinamay Kasaredy, David Tait, Michael Wright and Ethan Van Horn. Lastly, we are very grateful for the students at The Basic School who volunteered for this study.

Accelerated Learning Model for Increased Decision-Making Effectiveness in Unstructured Situations

Military leaders and decision makers often face challenges that come from the introduction of new missions, tactics, and personnel. Military training must address these challenges in a rapidly changing environment. Some years ago, the Defense Department's Science and Technology Advisory Group (DSTAG) called for a study of emerging concepts for rapid yet effective training that could aid military leaders as they sought to accelerate learning, especially in the domain of tactical decision making. (Andrews, 2009). Tactical decision-making expertise is difficult to learn because there are so few opportunities to develop tactical plans and execute them in formal training settings. Most novices (in this case junior officers) do not get many training opportunities in real life until later in their careers. (Chi, M.T.H., Glaser, R., and Farr, M.L.(Eds.) (1988).

To address the DSTAG's questions, a multi-service team of training experts was assembled, consisting of training research psychologists and training developers from the Office of the Director of Defense Research and Engineering, Air Force Research Laboratory, the Army Research Institute for the Behavioral and Social Sciences, and the Naval Air Warfare Center – Training Systems Division. The team examined the existing research literature and presented to the DSTAG their findings and recommendations. The researchers determined that two key learning theories were applicable in accelerating the acquisition of expertise: Cognitive Flexibility Theory and Cognitive Transformation Theory.

The Cognitive Flexibility Theory asserts that cognitive flexibility is the "ability to represent knowledge from different conceptual and case perspectives and then, when the knowledge must later be used, the ability to construct from these different conceptual and case representations a knowledge ensemble tailored to the needs of the understanding or problem-solving situation at hand." (Spiro, Feltovich, P.J., Jacobson, 1992, p. 58).

The Cognitive Flexibility Theory core syllogism argues that learning is the active construction of knowledge, the elaboration and replacement of mental models, causal stories, or conceptual understanding, Training must support the learner in overcoming reductive explanations, reductive explanation reinforces and preserves itself through misconception networks and through knowledge shields, and advanced learning is the ability to flexibly apply knowledge to cases within the domain. *Therefore,* instruction by incremental complexification will not be conducive to advanced learning, and advanced learning is promoted by emphasizing the interconnectedness of multiple cases and concepts along multiple dimensions, and the use of multiple, highly organized and multi-modal representations.

Cognitive Transformation Theory (Klein and Baxter, 2009) is similar, asserting that "We may attempt to define the cues, patterns and strategies used by experts, and try and develop a program to teach people to think as experts". "A different approach to skills training is to teach people how to learn like experts" (Klein, 1997, p. 37).

The Cognitive Transformation Theory core syllogism argues that learning is the active construction of knowledge, the elaboration and replacement of mental models, causal stories, or conceptual understanding, all mental models are limited. People have a variety of fragmentary and often reductive mental models, knowledge shields lead to wrong diagnoses and enable the discounting of evidence, and training must support the learner in overcoming reductive explanations and constructing adaptive mental models and approaches.

For this study, we incorporated both these models and operationalized them through a virtual world experience that provides an openness of the solution space with immediate feedback for the user. The user must achieve an over-riding non-negotiable goal (in this case mission success) in an unfolding situation, determining their own actions at each stage. During this experience, every micro-decision is scored against a novice to expert model for that domain. The score is determined by where the decision falls on the novice-expert continuum (DiBello, L., and Missildine, W. (2011). While going through the simulation, the user experiences immediate feedback in low density form; in this case every micro-decision results in on-screen traffic lights where "green" is expert, and "red" is either the wrong approach or something a novice would do. The consequences of both good and bad decisions also play out. In this simulation, for example, an officer making a bad call may have the order overridden or may be reprimanded. Users also experience latent feedback, where failure to plan for eventualities can result in a change in the opportunities of unfolding action. Meanwhile, the scoring details are collected in the system's backend and the user gets a comprehensive feedback report after the exercise (Rothwell and Kazanas, 2004).

This design allows for many types of learners at various levels of experience to enter the problem space at their own level, using their own method of approach, e.g. methodical analysis before trying things, random trial and error, focused trial and error based on experience, etc. (DiBello, 2019 and 2024). The key takeaway is that the method "selects" only those approaches that have the most benefit and helps the learner develop a mental model of the situation that helps him or her adapt. The idea is to “pull the learner forward” to be more like an expert in his or her thinking. While the accelerated approach can apply to learning problems of various types, it works most optimally in loosely structured problems that require higher order cognitive skills (e.g., problem solving, decision making) (Gagne and Medsker, 1996).

Practical benefits for military decision makers of accelerated learning capability. This research project’s outcomes will help military decision makers by providing instructional guidelines for rapidly constructing relevant instructional approaches for tactical decision making (Ward, Suss, and Eccles, 2009), a skill measurement system tailored for relevant decision-making competencies that is automated and objective (Stazewski, 2008), synthetic training environments that allow these skills to be trained anywhere the trainees are located, and synthetic environments that can be used to conduct mission rehearsals that are too risky to rehearse any other way.

Research Method

The research team trained volunteers (Lieutenants at The USMC Basic Officer School) in the skills of amphibious ship Well Deck operations, convoy operations, and EABO, via the FutureView™ Platform (a 3D immersive virtual environment based on cognitive transformation principles). Training scenarios were designed to provide the junior officers with experience in decision-making for these kinds of missions, in coordination with Naval Officers. Specifically, the content focused on dealing with uncertainty while preserving mission goals. The learning objectives and measurement system were selected after collaborating with key school leadership.

Accelerated Learning Development Process

The missions for the study were developed by TBS instructors, and with the help of a technician, were input into the platform using the No-Code scenario creation and editing tool. The No-Code scenario creation and editing tool then allowed the team to iteratively make refinements to both the flow of the mission, the challenges the trainee would face, and the scoring metrics.. For convenience, the missions were divided into “chapters” or scenes, making it easier to conceptualize the mission flow and make edits. Some specific requirements came from TBS.

1. The simulation reinforces the orders process TBS students learn as part of the Basic Officers’ Course. The student receives a warning order, intelligence briefing, and a 5-paragraph order.

2. The student is challenged to critically analyze information received to develop their order, set priorities of work, make reconnaissance, and complete the missions.

3. The chosen operational environment creates gray-area for the students to navigate, requiring them to exercise executive level decision-making to accomplish the mission in accordance with the commander's intent.

4. The Mission begins on the ship with planning activities and interactions with naval personnel.

In general, the content was based on TBS amphibious operations coursework, motorized operations coursework, and EABO coursework. As mentioned, all decisions were “tagged” with capabilities TBS currently uses to rate trainee performance. Dimensions include proficiency, initiative, ensuring well-being of subordinates, effectiveness under stress, decision-making ability, judgement, and communication.

Training scenarios were generated through a multi-step process that included:

1. Problem framing with TBS
2. Learning materials audit
3. Domain expert data collection
4. Scenario framing
5. Simulation development
6. Simulation validation

The process started with an open discussion with TBS to frame the problem. In this discussion, TBS identified training gaps, both in terms of training support and learning mastery. Based on the identified gaps, our development team and TBS identified training evolutions that could be reasonably addressed via the FutureView™ platform. The TBS team then designed "missions" that would expose students to experience that would address these training gaps. The idea is that reality analogous experience in the context of a mission is the best way to learn.

The next step was an audit of the learning materials to ensure service requirements were met. Relevant classroom learning materials (written and multimedia) and field exercise learning materials were reviewed. Natural points of cross-pollination were then identified to maintain continuity of the TBS learning continuum. After the initial assessment, we confirmed the validity of findings to ensure the terminal learning objectives (TLOs), enabling learning objectives (ELOs), and Training and Readiness (T&Rs) standards were correctly identified.

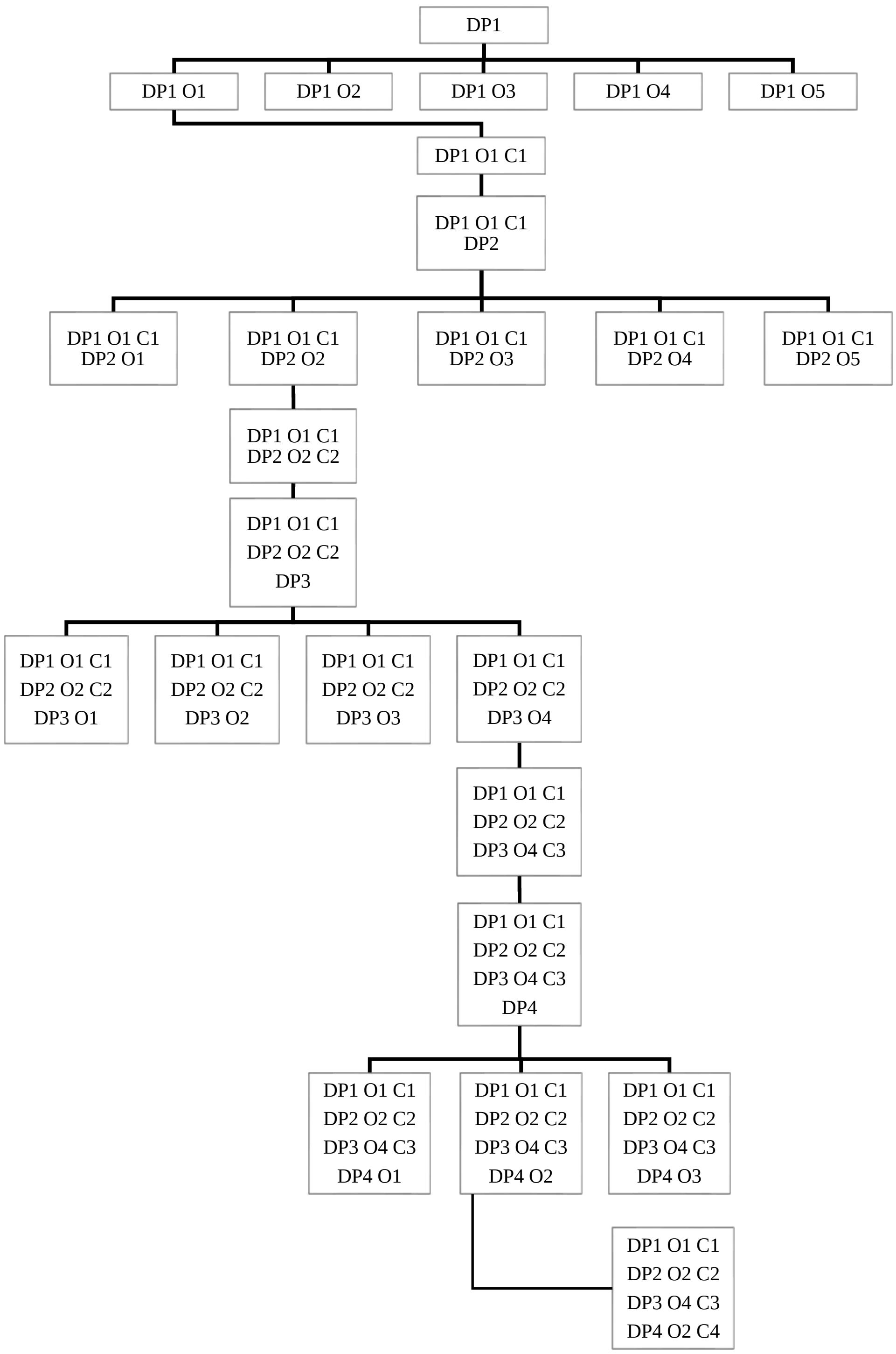
After the TBS staff provided the initial guidance on exemplary missions, scenario context, injects, and difficulty, the development team created an outline for TBS approval. The outline divided the entire mission profile into chapters, enabling a clear path to using the Node Editor to create the environment. The outline for each chapter included the location, heuristically relevant characters, contextual reference points to drive decision-making, and stimuli to inject. Once the high-level outline was complete, the TBS staff reviewed the outline ensuring the previously identified Terminal Learning Objectives, Enabling Learning Objectives, and Training and Readiness objectives (TLOs, ELOs, and T&Rs) were accounted for, the training aligned with what students had been taught and practiced to date, and the training supported future training within the Program of Instruction (POI).

In order to tag the micro-decisions, each of the options presented were alphanumerically coded in accordance with the TBS evaluation rubric. There were nine categorical tags and one simple mean category. Examples of the categorical tags included "judgement, communication skills, and proficiency." After determining which category each option included (because there were many instances of overlap), the options were rated on a 5-point expertise scale. Important to note, since the subjects were lieutenants, they were expected to perform as if they had some knowledge, represented as Level 3. An example of a minimally acceptable "judgment" option was coded "J3". Were the same option to also meet the TBS criteria of proficiency, the option would be coded "J3, P3". The aggregate simple mean for the TBS rubric was "performance" which was determined by a simple mean of the aggregate score across all nine categorical codes. A graphic depicting a nominal decision tree (without categorical ratings) is below in Figure 1.

"C4", in the example below, shows where the student reached a natural conclusion to the stimuli after four decisions (DP4). Due to the vertical integration of the simulation, it was possible for the student to experience immediate negative/positive consequences for decisions made or to experience the consequences of earlier chapters in the "future". These included second and third order effects. The benefit of including second or third order effects was crucial to TBS's goal of fostering forward-thinking critical thinkers.

The final step in the development of the simulation was recursive validation. The simulation was piloted in house at the ACSI lab facility and at TBS. Due to the agile nature of the system, the development team adjusted the simulation in near real time in design meetings with TBS staff and SMEs. For example, the nominal decision tree in Figure 1 represents one of the five possible directions the student could have gone. Based on decisions made each student was afforded the opportunity to experience different aspects of the simulation. Some experienced corrective feedback from Non-player characters (NPC's), some experienced environmental repercussions, and some intuited optimal paths and experienced minimal friction, thus replicating real-world interactions and ramifications. Additionally, the developed taxonomy allowed for node traceability. Node traceability was key for identifying bug locations and node edits because the DP-O-C taxonomy created a geo-location within the sim that could be traced forward and backward.

As mentioned, the platform used in this study has automated behavior tracking in its backend. Our research indicated that tracking "micro decisions" and giving users immediate, low-density feedback (traffic lights in this case) is an important feature to the cognitive transformation theory and for testing what is hypothesized to accelerate learning. Therefore, granular behavioral tracking capability was built into the technology used for this research. The model of "expert" is not always known ahead of time with this kind of study, the scoring scheme used to measure experts can also be easily changed in the platform's backend using the No-Code Editor.



Key: DP – Decision Point
O – Option
C – Consequence

Figure 1. Graphic depicting a nominal decision tree (without categorical ratings)

It was vital to create an unbiased tool that could accommodate any kind of expertise. FutureView™ is built to accommodate any domain of expertise where SMEs can agree on what is an “expert” decision (Figure 2, Screenshots of two phases of the Mission). For this study, we used a five-point Dreyfus novice-expert scale and applied it to the ten categories TBS uses to evaluate students (Dreyfus, 2004). Each micro-decision option was assigned a “level” on the Dreyfus scale and tagged with the category(ies) that met the TBS criteria (for example, decision-making ability or effectiveness under stress).

Figure 2. Screenshots of phases of the Mission – Preparing the well deck of the ship and organizing a convoy once ashore

We recursively piloted the simulation with three groups of Marines at TBS in Quantico. The groups consisted of 12–20 Marine 2nd lieutenants at various points in the TBS Program of Instruction (some graduates awaiting Military Occupational Specialty school, some partially through the Basic Officer Course program, and some awaiting graduation). The first test had early versions of the first mission. The second had a much more complex version of the same mission. The third group went through two missions, both of which were highly complex, requiring up to 200 micro decisions per hour.

We examined the data for “movement” up the expertise scale from time one to time two. In other words, we looked for patterns of increasing “expert” choices from time one to time two. This was necessary because the simulations are different for each student. The premise of cognitive transformation theory is that iterative feedback from trial-and-error cycles promotes the “unlearning” of erroneous or deleterious assumptions as much as “learning” alternative, more productive paths. Also, the simulation’s opportunities and flow of the play entirely depends on each student’s decisions. The intelligent agent system responds to the students’ choices, creating a unique experience for each student. For example, the same mission profile with the same starting point took one student 20 minutes and another student over one hour to complete. In this example both students reached the same conclusion, but it took the first student 60 micro-decisions (by taking a more efficient path) to get there and the second student more than 100 micro-decisions to get there with many of these decisions being “corrective” (Figure 3).

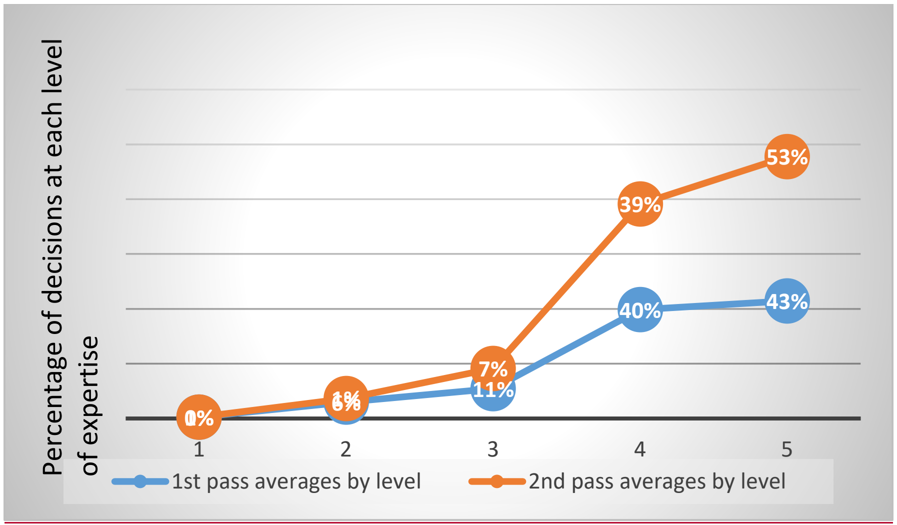


Figure 3. Average % of choices at each level across all participants, Time One and Time Two.

Using a t-test to look at the impact of the feedback we found statistically significant elevation of "expert" or "near expert" choices on the second try (t (25) =-4.91, p=0.000) for all groups (SD =<.0459). For the third group, this result was found on both missions (t (24) = -4.06, p=0.000) (SD = .09). The pattern of movement up the scale was similar regardless of the complexity of the mission experienced by each group.

All the participants could also fill out a survey on their experience. We desired to get feedback on the user experience.

General positive results from the survey

. All participants reported a feeling of immersion. They felt they were "on the USS San Diego".

. All agreed that the activities were realistic, challenging and engaging.

. All appreciated the instant feedback after each decision.

. All felt better prepared for a similar mission in real life.

. All agreed the planning portions provided valuable insight into the whole mission and everyone's role.

Two negative points that some respondents made:

- It would have been helpful if the trainee could perform the training with a teammate(s) as they likely would in an actual ship operation.
- It would have been helpful to receive 'hints" about the correct answers when they made the initial mistakes in their decision making. The system did give helpful hints but only after the entire training exercise was completed. Some of the trainees would have preferred to have received the hints as they made the mistakes.

Highlights from comments on the feedback survey

. “I felt it was very beneficial to introduce us to ship to shore operations.”

. “The immediate feedback helped me revise my thinking and consider a better approach.

. “The planning aspect of this simulation was very realistic and offered a view into the planning process.”

. “In my second attempt I fixed key mistakes from the first attempt and did not waste time on things that were not important.”

. “I learned to ask the right questions and what information was absolutely vital.”

. “This will definitely help junior officers be more prepared and become confident in their abilities, especially with multiple reps.”

Summary and Conclusions

Our research showed that using a method of training that is based on cognitive transformation in which the participant is “pulled forward”/learns with feedback that gives them insight into how their behavior differs from an expert model would be the most effective. The capabilities of the platform used fit nicely with that approach. In addition, The Basic School leadership was able to develop and implement their own missions with little technical assistance. The developed mission includes coordinating with Naval officers for mission planning, communications, a Rehearsal Of Concept (ROC), preparation of convoy equipment and amphibious equipment, and developing a Warning Order as well as other key aspects of such a mission. A random event generator introduces uncertainty that players need to react to while still accomplishing the mission.

The Basic School was also able to use their “Leadership Feedback Form” to automate the evaluation for each officer. Using the No-Code editor, the scoring scheme can be easily changed as requirements evolve. This has been built into the scenario and results in automated scoring for each participant. The mission has both multi-player and single-player capability. TBS has chosen single player mode for testing. The same number of “roles” are involved in both, but in single player mode, the others are Artificial Intelligence bots.

The project provided evidence of how TBS could accelerate the learning of difficult to learn domains. The school plans to include the developed training in their future Program of Instruction. We believe it is possible that other parts of USMC training could make use of the outcomes of this project. We also believe that the techniques developed could apply to other military training settings where time is of the essence.

Retention of learning is as important as the acquisition and development of that learning. We desire to conduct a future study be conducted to examine the effectiveness of the accelerated learning model in fostering learning retention. Based on the application of the model to non-military training we believe retention is improved by using the model and in the instructional delivery tool.

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