Accelerating Learning in an Ill-Defined Military Setting with a technology that scales knowledge transfer

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ABSTRACT

Increasing complexity in many military roles may require increased cognitive agility in areas of situation assessment, strategic and tactical decision making as well as better skill interpreting information in order to evaluate the need for a change in plan. Significant research has shown that it takes years and many repetitions for an individual to gain the skills, knowledge and decision-making capability necessary to be deemed an expert in any of these areas. However, recent research suggests that this requirement can be accelerated. This paper explores a technology that embodies a learning model that may help military personnel develop the necessary capabilities much faster using virtual environments with granular feedback which have been shown to accelerate learning. The learning model leans on two existing cognitive learning theories (Cognitive Transformation Theory and Cognitive Flexibility Theory) for its research- based underpinnings. The learning approach makes use of a virtual world cognitive simulation platform to deliver the training. The technology platform has the added benefit of making it possible for Subject Matter Experts (SME's) to share their expertise by designing scenarios and likely outcomes based on their experience without having to be experts in learning theory. The technology platform is designed to structure the experiences according to accelerated learning principles.

Keywords: *Accelerated learning; Cognitive Flexibility; Cognitive Transformation , knowledge transfer*

Introduction

Increasing complexity in many military roles may require greater cognitive agility in areas of situation assessment, strategic and tactical decision making as well as better skill interpreting information in order to evaluate the need for a change in plan. The project is sponsored by the Office of Naval Research.

Using accelerated learning principles derived from Cognitive Flexibility Theory and Cognitive Transformation Theory, our goal is to develop training for USMC senior enlisted leaders in mission critical principles using ACSILabs FutureView™ technology as a training medium. Our research will measure a treatment and control group in a realistic combat simulation. The initial experiment to test the theory and approach will be completed by June of 2024.

As a result of this project we will gain greater insight into the effect of methods of training officers using scalable Metaverse technologies. We will be using a highly flexible agent-based virtual world platform shown to increase cognitive agility in other domains (FutureView™ https://acsilabs.org/an-overview). As part of the research, we are developing tools that make it possible for individuals with significant real world experience to share their intuitive understanding of their domain by creating scenarios in FutureView™ that are restructured by the FutureView™ tool to conform to Cognitive Transformation Theory. The goal here to scale advanced learning and knowledge sharing.

This project has two main objectives: 1. A main objective of this project is to develop an instructional model that will enable learners to accelerate their attainment of knowledge and skill compared with more traditional approaches to training. In addition, the developers desire to improve learning retention when this type of instruction is given. The second goal concerns capturing the mental model of Experts. Experts in general are not good at explicating how they make intuitive decisions. One of the benefits and downsides of intuitive expertise is that it is largely implicit and preconscious. Currently, there are many useful and rigorous methods of mapping out the implicit mental model of experts which have a long history and which are well tested, e.g., Shadbolt, N. R., & Smart, P. R. (2015). Hoffman, R. R. (2008). Militello, L. G., & Klein, G. (2013)l Militello, L. Klein, G., et al. (2018); Rowe, G., & Bolger, F. (2023). However, these are time consuming, require special skills, and introduce a layer between the expert and the application that invites misinterpretation or error.

We will address each of these concerns separately.

Accelerated Learning: The traditional systems approach to training development with its five phases (analyze, design, develop, implement, and evaluate) has been proven to be an effective system. However, in many cases, especially for higher order cognitive skills like decision making and problem solving, it does not provide a mechanism for learners to accelerate learning. Learning is an active construction of knowledge into mental models. Often the learner may form knowledge shields that might prevent the learner from improving or even replacing mental models that are not correct or need to be updated. These knowledge shields can lead the learner to make wrong diagnoses of novel events, and they can also lead the learner to discounting evidence. This discounting can lead to the learner using a mental model that is not appropriate for the situation or to wrong conclusions.

Reductive explanation reinforces and preserves itself through misconception networks and through learner developed knowledge shields. Flexible learning involves the interplay of concepts and contextual particulars as they play out and are influenced by cases of application within a domain.

The project team believes that two related theories of expertise might be able to allow learners to gain cognitive skills more quickly. The Cognitive Flexibility Theory (CFT) and the Cognitive Transformation Theory (CTT) represent somewhat related approaches to learning design. Cognitive Flexibility Theory (Spiro, Coulson. Feltovich and Anderson, 1988) posits that training must support the learner in overcoming reductive explanation. Reductive explanation reinforces and preserves itself through misconception networks and through knowledge shields. Advanced learning is the ability to flexibly apply knowledge to cases within the domain. Therefore, instruction by incremental complexification will not be conducive of advanced learning. Therefore, advanced learning is promoted by emphasizing the interconnectedness of multiple cases and concepts along multiple dimensions, and the use of multiple, highly organized representations.

Cognitive Transformation Theory (Klein and Baxter, 2009) posits that learning consists of the elaboration and replacement of mental models. Mental models are limited and include knowledge shields. Knowledge shields lead to wrong diagnoses and enable the discounting of evident. (Feltovich, Coulson, Spiro and Adami (1994). Therefore, learning must also involve unlearning.

The project team believes that both of these theories contain key elements that when combined can help to design instruction that will accelerate the learning process. CFT suggests that for expertise acceleration, feedback must help the learner transcend their inclination to invoke a knowledge shield, and CTT suggests that feedback must help the learner unlearn concept or notions that incorrectly simplify their understanding of the domain.

Research on the nature of intuitive expertise and Accelerated Learning

Significant research has shown that it takes years and many repetitions for an individual to gain the skills, knowledge and decision-making capability necessary to be deemed an expert by others in the field. Recent research suggests that this requirement can be speeded up. Two questions come to mind: Given recent research on accelerated learning in specific domains (Hoffman et al 2014), can expertise that took years take only days or weeks? and 2. What are the implications for expertise in broad cognitive capabilities; can we accelerate expertise in areas of situation assessment, strategic thinking, tactical agility or general cognitive agility? It's a key question because the world is moving faster. Technological, military, political, business, and education domains all are moving along now at a quickening pace.

Increasingly, military personnel are in situations that require decision- making and problem-solving skills, and judgment far beyond what they normally would be asked to do as military officers. It isn't possible to send these officers for training in these skills and tasks over a period of many months for every situation that may arise. What kind of training could prepare these young officers to rapidly respond to the challenges? Accelerated learning techniques provide some good answers.

The interest in accelerating the mastery of expertise has a long history (Chi, Feltovich, & Glaser, 1981; Chi, Glaser & Rees, 1982; Glaser, 1987). Schneider et al (2002), posited that those who are considered experts are qualitatively different from novices, and journeymen, and the process of becoming an expert takes years . He claimed that training that takes a traditional route would not enable novices and journeymen to achieve the highest levels of expertise. Rather than traditional methods of training, the instructional designer and trainer must plumb the depths of learning strategies of those who would be experts. However, recently there has not been interest in this area of research, as evident by the dates of the publications referenced. Perhaps, it time to revisit this are with the research described in the proposal. The could lead to an updated model of the acquisition of expertise that would lead to more advanced training environments.

Accelerated learning model

Our view of expertise is that it is the result of stage-like development in the sense of Piaget (1977) and the functional invariants identified in his research, but with the influence of what Vygotsky (1978) would now call socially constructed domains. In other words, expertise develops through a series of stages, but the content is guided by the nature of the domain itself; i.e., experts "enter" into a way of understanding the world already in place for other experts of a specific kind, e.g., physicists.

Domain specific expertise is assumed to occur over time, as problem solving activities develop in-depth understanding, mainly through the accumulation of experiences from which patterns or similarities can be recognized. Our hypothesis is that a minimum number *of iterative trial and error activity cycles of a specific kind* are required for expertise rather than chronological time (DiBello 2019) and that expertise is a "first principles" understanding of the underlying organizing conceptual structure of the domain. Chronological time or structured "practice" may play only a minor role. The iterative cycles have special characteristics:

- The learner solves a problem or tries to achieve a complex goal, with the goal being front of mind.
- This must be accomplished under time pressure
- The learner is free to try anything he or she thinks might work in the problem space.
- Feedback is clear and objective, often graphically represented.
- The activity is immersive and usually involves multiple kinds of cognitive processes.
- Lastly, the goal is complex and multi-dimensional and achieving it must be non-negotiable.

An outcome of our research is a model of learning or a kind of "learning grammar" that has specific features which have been shown to be critical to accelerating learning. The features of the learning model are detailed elsewhere (e.g.., see DiBello 2018; Hoffman et al 2014; DiBello 2011). In general, the idea is to promote iterative trial and error in a relatively unstructured way by compelling a participant to achieve a non-negotiable goal which is highly structured and immovable. The participant is not "instructed" but rather is given the opportunity to try whatever he or she thinks will work, and given numerous tools and options, including things that won't work. Critical to the method are

1. Time pressure and
2. Highly granular and immediate feedback on the results of actions taken as well as the participant's progress toward the goal.
3. Relatively unlimited options for trying different methods of solving the problem.

An outcome of our work is a learning model that may have general applicability and a technology platform that supports the advanced behavioral tracking and feedback that is critical to its success. This project explores the general applicability of the learning model for building capability among teams and individuals through accelerated expertise. It also begins the development of tools for helping the sharing of expertise and knowledge through easy-to-use methods of importing meaningful scenarios.

Figure 1 presents the architecture of the elements of the Future View platform. Figure 2 presents some sample views that a trainee will see when using Future View. `

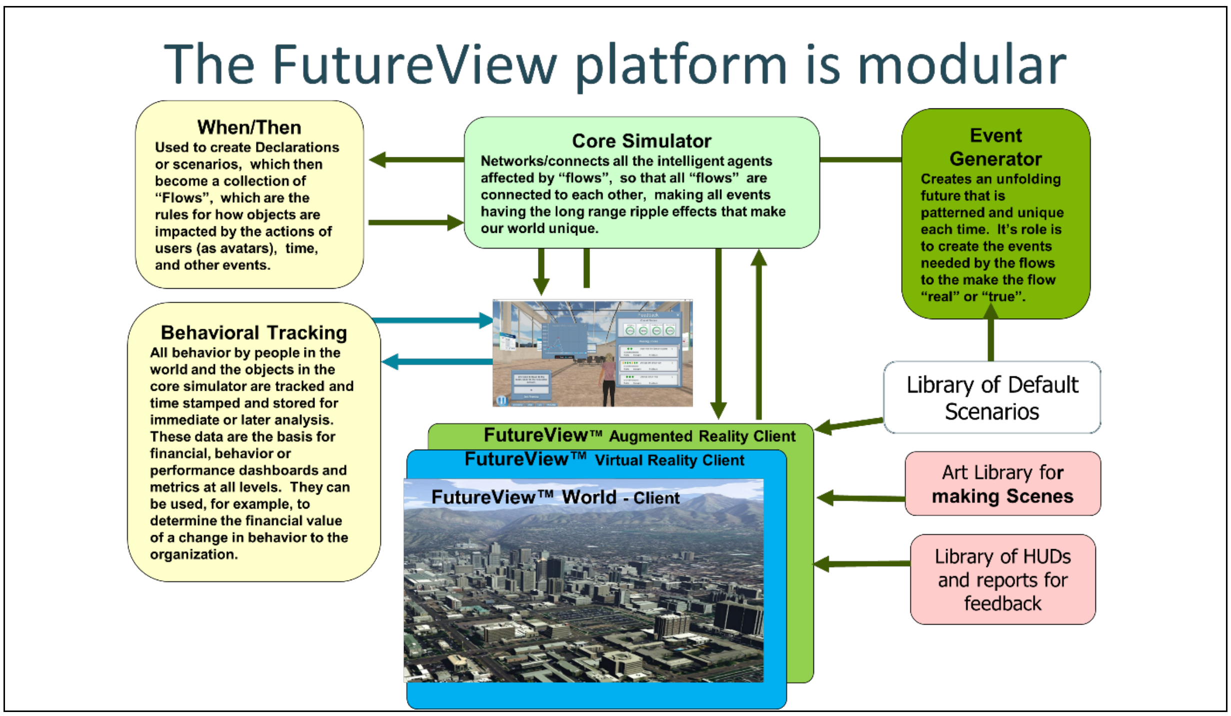

Figure 1. Architecture of the software that supports the learning model

Figure 2. Examples of scenes created for USMC Basic School's Mission

We are currently testing this model with the assistance of the US Marine Corp Basic School in Quantico. Using a scenario that they designed, we will be conducting studies on volunteers at the Basic School

The plan for the next phase of this work is to test the subject groups on the effectiveness of the learning model, using parametric statistics.

- The experimental group will be given instruction designed using the accelerated learning model described below with special emphasis on making rapid decisions when faced with uncertainty while still accomplishing the overall purpose of the mission. The instruction will be given to them on the FutureView™ platform which will allow for individual practice in realistic combat scenarios on a home or laptop computer. Each subject will then have their performance evaluated by USMC Basic Training School instructors.
- The control group will receive instructor led training in an online version of the scenarios in the FutureView™ platform, but the instruction will not include the elements of accelerated learning. Their performance will then be evaluated by instructors using the same scenarios as are used by the experimental group. Again, similar metrics will be used in both training venues. Time to learn and objectives accomplished will be measured for the control subjects.
- The statistics compiled for the evaluation will be used to determine if the accelerated learning approach using FutureView™ produces better results than the control group. In other words, those who went through the FutureView™ system should have a measurable advantage in the live training in the area of making decisions in uncertain situations.
- Instructional strategy and materials will be prepared based on cognitive models of urban operations that have been developed from the Cognitive Task Analyses conducted during prior phases. These posit that cognitive models and templates when they are formed and used have various conceptual errors and they need to be corrected if advancement toward expertise is to take place. The accelerated learning model seeks to first elicit the cognitive model(s) used by the novice and journeyman and then to elaborate and replace mental models that are incorrect.

Capturing the knowledge of experts

Working with The Basic School also afforded an opportunity to see if we could find a way to rapidly design scenarios that had more realistic features. As mentioned**, a** key constraint is understanding the implicit mental model of experts in order to have realistic scenarios and feedback which "pulls forward" learners who go through challenges and learn how they are different from experts. This is critical to the implicit scoring and feedback model in FutureView. After working with experienced officers and warfighters and conducting cognitive interviews, we realized that what was needed is a way to have the experts create the scenarios themselves. This happened when we attempted to interpret their experience, we were only partially successful. In the beginning, we would create scenarios and get their feedback after they "played through" the challenges. We always got something wrong.

The development team decided to make a toolkit to make it easier to make changes rapidly without writing new code. This "node editor" allows Experts to create scenarios of their own and give items in the scenarios "agency" to know when an "expert" response occurred, or if the response was novice-like, or somewhere in between. In addition, the long tail ripple effects between decisions and consequences could be designed using the logic in these scenes, manipulated by the node editor. For example, in military settings, a failure to issue an order in clear and concise terms could result in a misinterpretation of the command leading to executing on a flawed theory of the goal (the subordinate getting the "order" is an A.I. bot). At first we thought using the Node editor would be overwhelming, but Experts are, in general, not overwhelmed by detail that they manipulate easily in real life. With some simple "rules" and some technical assistance with the node editor, they were able to design powerful experiences that went far beyond what we could do. The following "rules" for making scenarios leveraged the capabilities of the platform and ensured that cognitive transformation occurred.

- Make a "story" such as mission in which you would expect novices and experts to handle the challenges qualitatively differently. It should include 5 to 12 "chapters" or scenes.
- Design at least 65 decision points that users would have to encounter
- Define on a five-level scale the level of expertise for each option for each decision point.
- Decide what would constitute "success" for the mission or story overall.
- Provide a list of "injects" that would be reasonable for this story that would vary the flow of the play if randomly presented.

The Marines at the The Basic school had no difficulty with this task, and decided to use the current Officer Evaluation form, which scores officers on six parameter to guide the scoring. The platform is designed to capture all behavior and automatically score all decisions and give immediate feedback. It also "remembers" the long tail consequences of all decisions and rolls out the consequences automatically. By the time they were done, the evaluation was automated. Development areas could be clearly identified. Any scoring rubric that was not a good fit could be fixed in minutes with the Node Editor.

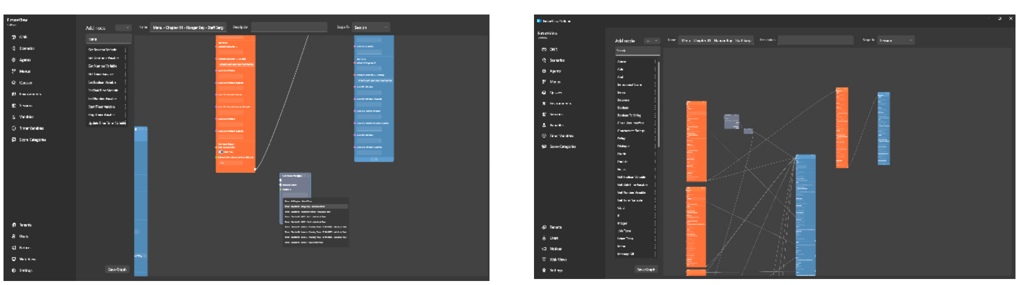

Figure 3. Screen shots of an expert using the Node editor to instantly modify scenarios and built intelligent agents with properties, logic, History and memory.

We are in the early stages with this approach and plan to collect more data for the rest of 2024. However, the early feedback is promising, especially with the Experts using the tools to design meaningful experiences that both reveal expertise and accelerate learning.

Learning and retention measurement

While there are a variety of "expertise" skills in existence with varying anchor points, the most important goal is to find and use one that support measurement systems that can be built to help place a person on the scale. Further, we need methods of creating experts that can be quickly developed, and once developed, be used at scale. We have attempted here to address both needs. The outcome of this work will tell us if we are on a good path.

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