AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

THE HAPTIC SOLDIER: IDENTIFYING THE MISSING VIRTUAL REALITY COMPONENTS TO SUPPORT COGNITIVE TRAINING

by

Cody S. Pilger, Major, USA

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements

Advisors: Dr. Dennis Armstrong & Col Tony Millican

7 April 2019

The launch of the Oculus Rift CV1, in March of 2016 to the consumer market, brought Virtual Reality (VR) to the front page of the world. At this time, VR was not a new thought or technology. The military and academia have study and utilized it for nearly two decades. Jeremy Bailenson, a Stanford University professor and director of the Virtual Human Interactive Lab (VHIL), has conducted numerous studies on the use of VR and the immersive environment. He cautions that the few understand how the technology affects the brain and the full capability of its usefulness.1 The release of a consumer VR product now provides the masses with an affordable powerful technology that can further advance the development and study of the immersive environment on the human brain.

The US military has utilized immersive or VR environments for decades to train soldiers, sailors, airmen, and marines. The release of a viable consumer grade option to the public will bring more research and applications into the uses of VR and allow for adaptation of this research and technology to enable the war fighter.[2] This along with the premonition that future war fighters will enter into service with some exposure and usage of VR, creates an ideal opportunity for the development of VR based training.

As Bailenson predicted, more research and applications are being developed for VR. Due to the increased availability of VR technology, this research and development of new applications and devices is exponentially increasing. The past saw the development of these advancements in labs and large corporations. The successful development of Oculus by Palmer Luckey, as identified by Greg Kumparak, provides another example for small "indie" developers of both applications and technology that they can break into the technology industry.[3] Today, we find numerous open source free software and affordable technology that allows for smaller developers to compete with large corporations.

What does all of this mean to the US military? We contend that it offers more technology-based options for future training. The US Army reconfirmed its commitment to using emerging technology with its awarding of a $480 million contract to Microsoft for its HoloLens augmented reality devices.[4] The future question for the US Army will be how does it utilize these emerging technologies to train the war fighter.

Background

The US Army currently utilizes two training simulators to train dismounted infantry units. The first system, Virtual Battle Space (VBS) 2™ is a realistic battlefield first person shooter type simulator. The second system is the Army's Dismounted Soldier Training System (DSTS). DSTS is an immersive environmental training simulator dedicated to training dismounted infantry units. DSTS originated from a 2008 US Joint Forces Command (USJFCOM) program called Future Immersive Training Environment (FIFE) Joint Capability Technology Demonstration JCTD. At this time, the USJFCOM saw a need to demonstrate the value and potential of immersive training system and fill a training void that the wars in Iraq and Afghanistan created. FIFE was the USFJCOM tool to address the operational problem of: "Military trainers have insufficient enablers to train close-combat tasks in a realistic, fully immersive training environment that creates and reinforces complex (tactical and human dimension) decision-making skills."[5] FIFE JCTD set an ambitious FY10 goal to develop a solution that met seven specific criteria:[6]

> 1. Replicating elements and conditions of the battlefield across the full spectrum of operations in order to improve situational awareness, cognitive skills and higher decision making.
>
> 2. Allowing team members to exercise close combat tasks in a realistic, fully immersive training environment that reinforces ethical and legal decision making against an asymmetric enemy employing IEDs, criminal networks and insurgency tactics.
>
> 3. Providing culturally-realistic, dynamic, synthetic entities that allow realistic interaction within the operational environment, to include friendly units, hostile forces and civilians.
>
> 4. Supporting repeatable and rapidly reconfigurable scenarios and training systems or ranges.
>
> 5. Providing realistic threat cues, indicators and features to enhance situational awareness in order to improve predictive capability to identify enemy threats.
>
> 6. Supporting trainees' ability to request, control, and coordinate supporting arms and Intelligence, Surveillance, and Reconnaissance (ISR) resources within the training scenario.
>
> 7. The ability to record and playback each entity's movements, orientation, and communications to provide in-depth AAR.

FIFE JCTD was concluded in 2010 and demonstrated that the seven criteria reached an acceptable level of performance. DSTS was the Army's program of record that was developed following FIFE JCTD and was formed by some of their results. Since its fielding in 2012, DSTS has under performed in providing an effective training environment for dismounted infantry units.

<u>Issue</u>

The US Army's current Virtual Reality (VR) trainers are outdated, overly complex for combat Soldiers to utilize, and do not provide realistic training. Army doctrine states that training needs to be tough, realistic, and challenging. The current limitations of haptic devices are not providing a solid cognitive learning environment for Soldiers to train within. Virtual reality is a prime medium to assist in training warfighters in in accordance with cognitive learning theories, but the lack of haptic devices restricts the ability to fully utilize it. In order to accomplish this, further research and development into the specific haptic devices that assist and create a realistic training environment for Soldiers needs to be initiated.

The US Army is spending millions of dollars a year for simulations that do not accomplish the tasks set forth by the Department of Army for standardized unit level training for the dismounted infantry units. The significance of this research is to identify a couple of possible solutions and a lay the ground work for future research to incorporate VR combat simulators.

Learning Theory for Military Training

The first criteria of the FIFE JCTD FY10 criteria was to replicate battlefield conditions to improve situational awareness, cognitive skills, and higher decision making. The use of VR as a learning tool can help to reinforce cognitive skills as laid out by the FIFE JCTD. To this point, understanding what the cognitive learning theory is and how with the use of VR the US Army can meet the FIFE JCTD intent in developing future VR systems.

The training that the US Army currently conducts, at the individual and collective task levels, is based off of the behaviorism philosophy which was the highly researched in the 1940s and 1950s. Since then, new research is expanding on this philosophy and revealing the way that the brain functions. For the most part, the US Army still follows this early philosophy in its training and is evident in the current training doctrine even thou it does not specifically call out the behaviorism philosophy. Its fundamental characteristics are littered throughout the page of past and portions of current doctrine.[7] For the purposes of this paper, it is assumed that current research reveals the benefits of a better trained force when using constructivism philosophy to train Soldiers and tactical leaders to observe, analyze, and act when engaged in the wars of the futures. This paper also does not propose a solution to how the US Army should adjust its training and doctrine from a behaviorism to constructivism philosophy. Instead, this research will examine how VR can reinforce constructivism-based training with the cognitive learning theory.

A simple definition of the constructivism philosophy is a way to promote learning through active participation of the students. Richard Meyers, a professor of psychology from the University of Santa Barbara, defines the constructivist learning as "when learners actively create their own knowledge by trying to make sense out of material presented to them."[8] This concept of learning can be traced back to the practices of Socrate's dialogues. This was the practice of allowing self-realization by question or challenging the logic of his followers.[9] Ultimately, constructivist believe reason is the source of knowledge and instead of discovering it individuals construct knowledge. Within the constructivism philosophy there are two components that are subclasses of both cognitive and social psychology.

The two subclasses of the constructivism philosophy derive from the thought that students best learn when engaged with either their peers or the environment. Cognitive constructivism was originally promoted by Jerome Bruner. His research points to the understanding that students best learn to construction new knowledge based on previously experiences and that encouraging students to have an active Socratic learning environment.[10] The second subclass, social constructivism is championed by Vygotsky. He looked to understand how social and mental activities through cultural constructed artifacts contributed to the constructed learning of the student.[11] Together both of these subclass create a wholistic approach to the constructivism philosophy that promotes students to actively construct knowledge based on personal and social experiences to enhance and increase the capacity of learning while increasing the students ability to retain and utilize this knowledge in future situations.

The US Army currently practices the philosophy of behaviorism, as previously discussed, in training its war fighters. This really means "learning has occurred when learners display the appropriate response to a particular stimulus."[12] The problem is that the students may not learn or understand how to respond if the particular stimulus is different than what they were trained on. The uncertainty of future warfare and situations that the Soldier may find themselves in requires Soldiers to be able to adaptively think and respond to a wide variety of stimulus. The constructivism philosophy helps to develop this sort of thought. The US Army is slowly recognizing this in its most recent training doctrine. Even though it's not specifically recognized the wording of the constructivism philosophy is evident – "A team is more effective than an individual is at achieving results. When Soldiers work together, they use their unique skills, experiences, and capabilities together to achieve task proficiency."[13] Both the behaviorist and constructivist approaches meet the objective of training the warfighter, but the constructivism philosophy allows for greater solutions for the warfighter to choose from.[14] Thus, creating an environment for Soldiers to identify, responds, and win with the changing warfare of future wars.

Understanding that the constructivism philosophy is the ideal philosophy to produce the current and future war fighter that thrive in ambiguous, complex, and challenging situations, the question turns to what learning theory will create the optimal training events and scenarios. More specially, what learning theory does VR reinforce to supports the FIFE JCTD FY10 criteria? Maj Andrew Jenkins wrote on the specific topic of learning theories best suited to encompass the constructivism philosophy in training the US Army. Maj Jenkins is an Army Officer and winner of the 2016 DePuy Special Topics Writing Competition and holds a ME in learning design and technology. He contends that "we (the US Army) can use a more cognitive learning theory to design training events and scenarios."[15] It would be sensible assumption that to meet FIFI JCTD criteria of "improving cognitive skills" that future warfighter training is developed according to the cognitive learning theory.

To reinforce the use of the constructivism philosophy when training the warfighter, Maj Jenkins recommended the cognitive learning theory be used in developing the training events and scenarios. A learning theory tries to describe what happens when people learn and allows for strategies, tactics, experiences, and learning environments to develop around the theory.[16] Even though the US Army distinguishes learning and training separately in doctrine, it is useful for trainers to understand learning theory to better tailor their training events. For the purpose of this paper, we will use the cognitive learning theory to analyze if VR can effectively train dismounted infantry Soldiers in individual and collective tasks.

There are numerous researchers examining and documenting the cognitive learning theory. To scope the massive amounts of data available a baseline understanding of the cognitive learning theory needs to be defined to understand how to best analyze if VR is the right medium to train the dismounted infantry Soldier. Agonstino Bruzzone and Marina Massei define the cognitive learning theory, in regards to military training, as being:

> …devoted to prepare trainee in applying proper procedures and instruction at cognitive level. This is supposed to be effective based on the hypothesis that cognitive abilities are maintained and improved by exercising the brain, in analogy to the way physical fitness is improved by exercising the body. A classical example is to us a constructive simulation to solve a tactical problem.[17]

The cognitive learning theory is best used to help "learners recall new information, comprehend how things work, and remember and use new procedures."[18] It is a theory of trying "to understand the understanding."[19] This approach helps the warfighter to process, store and retrieve information from the long-term memory, allowing them access and to process information during highly stressful combat operations.

The cognitive learning theory is a way to ingrain deep long-term knowledge into the warfighter. The implementing of the cognitive learning theory and how it relates to training is best examined through the five learner tasks associated with the Cognitive Training Model. These learner tasks are what the individual must do to learn the information. The five tasks are: select the information to attend to, link the new information with the existing knowledge, organize the information, assimilate the new knowledge into existing knowledge, and strengthen the new knowledge in memory.[20] Maj Jenkins argues that "quality instructional design based on the constructivist philosophy and cognitive learning theory promotes cognitive processes that lead to learning."[21] To validate this argument, the final piece of the learning triad is understanding instructional design.

Instructional design is a group of events that need to be completed in each act of learning. Robert Gagné, one of the founding fathers of instructional design, developed nine conditions of learning. These conditions are actually events that are required in every act of learning. These events are the bases for many of the Cognitive Training Model tasks. The instructional design conditions are also corresponding to the strengths of VR training. Take for instance, the first condition, gain the learner's attention, and the Cognitive Training Model's first task, select the information to attend, the immersive environment that VR creates pulls in and captures the learner. Therefore, setting the foundation for the training.

The US Army's training doctrine emulates portions of the instructional design in its newest publications. FM 7-0 states that "Units obtain effective training when they create a realistic and challenging training environment."[22] Creating the realistic environment reinforces Gagné's fifth instructional condition of, use methods to enhance understanding. This stores the underpinnings of the environmental factors into the cognitive training model that effects the constructivism psychology of the Soldier during the training event and etches the training into the long-term memory of the Soldier. A Soldier will recall their most memorable war stories from training events when the training was the most realistic. The training at the US Army's Combat Training Centers is some of the most talked about at the individual Soldier level. Training the Soldier for the ambiguity of the next conflict is reinforced but using instructional design to develop training events and exercises. Using the medium of VR to teach can enhance this training. VR allows for on the job training without exposing the untrained Soldier to the high risk of actual combat. It creates a simulated environment that immerses the Soldier, removes outside influences, and focuses the individuals to the training objectives.

<u>Training Management</u>

The FIFE JCTD's criteria for immersive training environments was initially developed for the current wars of the time where counter-insurgency operations were the main effort. Nine years later, the US Army has refocused training back towards near-peer high intensity conflict. Even though the FIFE JCTD's criteria were developed during this time they still have some merit in today's training environment. The problem now is that the Department of the Army has identified new training tasks that immersive training environments need to accommodate and are not always a line with the software and hardware developed for the FIFE JCTD FY10. As the US Army continues request units to utilize the virtual environment for training, new technologies need to be identified to support these requests.

The US Army has a standardized list of tasks that each unit must be able to accomplish at a certain level of proficiency. These tasks are known as Mission Essential Tasks (MET). METs are standardized across the US Army by unit type. To understand how VR and haptic devices support training a basic understanding is required for how the units train and are evaluated. Dismounted infantry units are classified, by the US Army, as Rifle Companies and the Department of Army has identified five standardized tasks that these units need to train.

A rifle company is expected to be able to "to close with the enemy by means of fire and maneuver to destroy or capture, or to repel his assault by fire, close combat, and counterattack."[23] The five standardized METs for a rifle company are: "conduct an area defense, conduct a movement to contact, conduct an attack, conduct area security, conduct expeditionary deployment operations."[24] Each of these task are broken down into subtasks that support the standardized MET. The US Army developed a standard tool to assist with unit training called the Combined Arms Training Strategy (CATS). CATS identifies 57 subtasks that support the five METs for a Rifle Company. Of these 57 tasks, 12 tasks are directed as virtual training events and directly support four of the five METs.[25] The Army identifies the use of virtual training by directing the required training aids, devices, simulations and simulators (TADSS) for training event. The 12 virtual related tasks recommend using multiple training simulators to include VBS, Reconfigurable Vehicle Tactical Trainer and Close Combat Tactical Trainer.[26] For simplicity, this paper will focus on training simulators that cater more towards dismounted operations such as VBS and will track the task of conduct an attack from squad to company level.

To conduct an attack, there are multiple sub-tasks that both the individual, team, and unit must accomplish to show proficiency in the task. The company level MET has five sub-tasks and include both the squad and platoon level tasks. The company is required to conduct supporting collective task of integrate indirect fire support, integrate direct fires, conduct an attack by fire, and conduct support by fire. Also included in the conduct an attack MET is several supporting individual tasks to include engage targets with an M249 machine gun and engage targets with an M240B/M240L. One additional supporting drill associated with conduct an attack is breach of a mined wire obstacle.[27] The training audience that the US Army states should benefit from the virtual training is the company headquarters, rifle platoon headquarters, rifle squads, weapons squads, and mortar section. This audience is diverse in both the skills they need to train and weapons systems that are used during training. The intended outcome of using the virtual environment to train this task is that "The unit demonstrates limited proficiency in applying tactics, techniques, and procedures, SOP items, and tasks related to conducting an attack, in a virtual/gaming training environment."[28] This is a long list of tasks with a lot of different requirements to fulfill a lofty expectation from the US Army's current digital training environment.

Digital Training Environment

The US Army's program of record for digital training environment is the Virtual Battle Space. VBS is a desktop computer simulation for training military operations developed by Bohemia Interactive Simulations to "provides a virtual training environment for land, air and sea training and mission rehearsal applications."[29] The program provides the training audience an immersive environment on a two-dimensional computer screen. VBS is modeled after high end commercial video games technology and is quoted to "presents cognitive training in a situational context, resulting in faster assimilation of content, increased retention, and integration of key training objectives."[30] Soldiers attend VBS training in a computer lab environment and control their in-game avatar by keyboard and mouse. Stimuli provided to the Soldier is through a set of headphones and visual cues on a computer monitor. This works to train leaders in understanding situational awareness and the art of mission command, but it lacks the full fidelity to train the entire unit and reinforce cognitive skills learned during training outside of the virtual environment. Thus, fails to capitalize the training time, which is already limited, for the entirety of the unit.

The concept of developing an immersive virtual training environment to train cognitive skills complex. The advancements in virtual reality software and hardware technologies in the recent years creates the opportunity to develop these complex environments. There are three major concepts to create an immersive virtual reality. The first concept is immersion. Immersion is understood as a way a participant is engaged in the digital environment by simulation that replaces the physical world. This is done through visual, auditory, haptic, and olfactory stimuli.[31] The second concept presence. Presence in the virtual environment is a sense of one being in the environment. The presence inside of a virtual environment is easily broken by "a mismatch of sensory stimuli, a lack of some sensory information, or an interruption of any kind could potentially reduce a sense of presence in a VE."[32] The final concept is user representation. User need to represented in the virtual environment by visual awareness and proprioceptive movement.[33] Virtual avatars and motion tracking help accomplish this. A lack of fidelity in the avatar or movement of the representation can break the presence of the user. Together, these three concepts create an immersive virtual reality that provides a medium to develop cognitive learning events.

Developing an immersive virtual training environment that accounts for the three concepts is challenging. Typically, virtual training environments for vehicle simulators have better success in military personnel. Vehicle simulators are able to isolate the user and environment creating a more immersive experience. Developing immersive virtual training environments for dismounted infantry training is more complex as the Soldier has direct contact with the environment. Dismounted movement is different than mounted movement as the user is controlling their body rather than a vehicle.[34] To interact with the environment Soldiers must be able to twist, turn, see, and move in 360°. The user interface for the virtual environment needs to account for this. Developing a user interface along with the haptic devices to create a sense of presences is where the challenge lies for creating an immersive training environment that effectively reinforces cognitive theories.

Movement and Sensory Haptics

There are two areas of the user interface that need to be discussed to better understand their limitations. These areas are critical to the user being fully immersed and interacting with the virtual environment. The lacking fidelity in these areas reduces the amount of presence the user has in the environment. The first area is focused on the movement of the user in the environment. Unlike vehicle training simulators the user physically moves themselves in the environment. The second area is focused on the user feedback from devices used during training. An infantry company has multiple tools they use to conduct a mission. Replicating each of these tools in the virtual environment is generally an easy task. The problems of, how does the user interact with these tools and how does that interaction enhance the immersive nature of the virtual environment, create the dichotomy for developing fully immersive environments for the dismounted infantry company.

The dismounted movement of the Soldier in the virtual environment has already been noted as a challenge when developing a user interface. The challenge for developers is how does the user interface accounts for the variety of movements that the individual make while training. The dismounted infantry Soldier will run or walk and may be in any position to include standing, kneeling, or in the prone. These properly conducting these movements and positions are key to reinforcing good cognitive habits.

There are multiple ways that training software currently deals with the dismounted movement of the user throughout the environment. One way is that the user utilizes a keyboard and mouse to move throughout the environment. Pressing a single or combination of keys on the keyboard will move or position the player in a predefined way. Typically, they will use a mouse to scan the environment. Using the keyboard and mouse to interact with the environment is the typical option utilized by large gaming companies and the VBS system. This may be the most efficient way to move the user in the environment but the lack of feedback creates a disconnect in the immersive nature of the training environment. A second way deals the use of a game controller or joystick to move the user around the environment. The advantage of this option is that most Soldier easily understand how to use the game controller. As with the keyboard and mouse option, the game controller option lacks the feedback and creates a disconnect in the immersive nature.

A third option to control the user is with a full-body-tracked system. This system accounts for the Soldiers movement and position, allowing the individual to interact with the user interface through their body motion. These systems are currently in development and range from sensors attached to the Soldier to sensors in a full body suit. Commercial entities in the US are using a modified full-body-tracked system that allows the users to roam freely in a large room and interact with both other users and the environment.[35] Even thou the full-body-tracked system is viewed as the optimal option there are a couple of problems associated with the system. The first problem is a sensory-motor mismatch which "occurs when the user performs an action and the sensory feedback."[36] The sensory-motor mismatch should be avoided and often times brings on simulator sickness. The second problem is a stimulus mismatch. The stimulus mismatch happens when the user's avatar fails to follow the user's physical actions creating a false user representation and breaks the immersion. Even with the shortfalls of the current full-body-tracked systems it is a solid option that allows the user's movements to be translated directly through the user interface to the virtual environment.

The way that user interact with tools is the second area of the user interface that needs to be identified. The dismounted infantry unit requires numerous tools to complete their assigned mission. The task of conduct an attack might require different tools such as weapons, demolitions, pyrotechnics, and any other specialized unit equipment. There are five different weapon systems that the unit may use when conducting the training event to include the M4, M249, M240B/L, M203, and 60mm mortar system. To create the immersive environment required to reinforce the cognitive training associated with the training event each of these weapon systems would need to have some sort of way for the user to interact with them in both the virtual and physical environment.

Haptic devices are the instruments that connect tools between the virtual and physical worlds. General haptic devices are things such as gloves and garments worn to provide tactile feedback.[37] This is done by feedback actuators that target points on the body to provide a tactile sensation. Haptic development is on going and the systems are getting smaller and more refined. Future devices may apply restriction and tactile feel to the user that reflects objects in the virtual environment.

A current option that is more widely used to connect the virtual and physical world is passive haptic devices. Passive devices are "physical objects to provide feedback to the user through an object's shape."[38] The Army's virtual VBS trainers utilize M4 weapons as passive haptics. The use of passive haptic devices helps to reinforce cognitive muscle memory of the items used in training. There are some disadvantages to using passive haptic devices that need to be identified. The first disadvantage is a large stock of different devices would need to be held to facilitate the required training. There is also the possibility of a sensory-motor mismatch that may occur if the device doesn't directly correspond between the virtual and physical environment. Finally, passive haptic devices may not be easily passible in the virtual environment.[39]

The dismounted infantry unit needs multiple haptic devices to reinforce cognitive training in an immersive virtual environment. Whether the devices are general or passive devices, the availability of a device is needed to create an immersive environment.

Recommendations and Further Studies

The current virtual training system for the dismounted infantry unit trains the leaders of the unit and allows them to understand battlefield geometry and practice the art of mission command. They fail to provide fully immersive virtual training environment. Future virtual training systems need to incorporate the ability for the Soldier to conduct movement that is not simulated and provides the proper feedback. The future systems also need to incorporate a combination of general and passive haptic devices. Currently, the use of the VBS system can be negated by field training that utilizes the Army's Multiple Integrated Laser Engagement System 2000 (MILES 2000). VBS in its current state does not reinforce cognitive learning at the Soldier level in the dismounted infantry unit. The only advantage that VBS has over field training is the ability to quickly change the scenario and provide a recordable After-Action Review of the simulation. Other combat VR systems may reinforce portions of cognitive training but still fail to create an immersive training environment due to the lack of a movement system and haptic devices. Even though the advancements to VR have exponentially increased over the last couple of years, there are still discrepancies that keep it from meeting the true intent of the FIFE JCTD's 2010 directive.

Further studies are needed to determine the feasibility of utilizing an immersive VR system in the training of MET for the dismounted infantry units. One specific focus, needs to identify how the movement of a Soldier will be translated from the physical to virtual environment to create the proper feedback to and not create a break in presence. A second focus, needs to identify ways to create haptic devices that increase the tool availability for the unit in the virtual environment while creating the proper tactile sensation to create an immersive training environment.

Conclusion

Since the release of the first Oculus system in 2016, VR devices and research has increased. The accessibility to VR is now greater than it has been in the past decade and the US Army is making an attempt at incorporating it into unit training. VR environments can reinforce the cognitive learning if the right feedback is available. The US Army's current systems, while good, do not create a fully immersive VR environment. If the requirement for a dismounted infantry unit is to use VR to conduct METL training, future systems needs to account for cognitive learning that is gained by the feedback provided by a movement system and haptic devices that create the immersive nature that VR can provide.

---

[1] J. Bailenson, *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do* (W. W. Norton, 2018), 11, https://books.google.com/books?id=2fkqDwAAQBAJ.
[2] Bailenson, 12.
[3] Greg Kumparak, "A Brief History of Oculus," Technology Review, Tech Crunch, March 26, 2014, https://techcrunch.com/2014/03/26/a-brief-history-of-oculus/.
[4] Joshua Brustein, "Microsoft Wins $480 Million Army Battlefield Contract," Bloomberg, November 28, 2018, https://www.bloomberg.com/news/articles/2018-11-28/microsoft-wins-480-million-army-battlefield-contract.

[5] US Joint Forces Command, "Future Immersive Training Environment (FITE) Joint Capability Technology Demonstration (JCTD) Management and Transition Plan (MTP)" (Norfolk, VA, 2009).
[6] Emilie Reitz and Kevin Seavey, "Virtual Dismounted Infantry Training: Requiem for a Dream," 2016, 3, https://www.researchgate.net/publication/312083833.
[7] Andrew Paul Jenkins, "Transforming Unit Training with the Science of Learning," *Military Review*, November 2016, 102.
[8] Charles M. Reigeluth and Alison A. Carr-Chellman, *Instructional-Design Theories and Models: A New Paradigm of Instructional Theory* (Psychology Press, 1983), 143.
[9] J. B. Juhary, "Constructivism: The Roots of Military Pedagogy?," *PEOPLE: International Journal of Social Sciences* 3, no. 1 (2017): 469, https://doi.org/10.20319/pijss.2017.s31.467480.
[10] Juhary, 472.
[11] Mamour Choul Turuk, "The Relevance and Implications of Vygotsky's Sociocultural Theory in The Second Language Classroom," 2008, 245.
[12] Jenkins, "Transforming Unit Training with the Science of Learning," 102.
[13] U.S. Department of the Army, *Train to Win in a Complex World, Field Manual 7-0* (Leavenworth, KS: Headquarters U.S. Department of the Army, 2016), 1–5, https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN9860_FM%207-0%20FINAL%20WEB.pdf.
[14] Jenkins, "Transforming Unit Training with the Science of Learning," 103.
[15] Jenkins, 104.
[16] Darryl L Sink, "Design Models and Learning Theories for Adults," 2014, 185.
[17] Agostino G. Bruzzone and Marina Massei, "Simulation-Based Military Training," in *Guide to Simulation-Based Disciplines: Advancing Our Computational Future*, ed. Saurabh Mittal, Umut Durak, and Tuncer Ören (Cham: Springer International Publishing, 2017), 317, https://doi.org/10.1007/978-3-319-61264-5_14.
[18] Sink, "Design Models and Learning Theories for Adults," 191.
[19] Sink, 190.
[20] Sink, 192.
[21] Jenkins, "Transforming Unit Training with the Science of Learning," 104.
[22] U.S. Department of the Army, *Train to Win in a Complex World, Field Manual 7-0*, 1–10.
[23] "Army Trainign Network - Combined Arms Training Strategy," accessed May 1, 2019, https://atn.army.mil/ATNPortalUI/CATS/ViewCats?catsIdentifier=b5f005e7-7331-48f0-88f1-0e80990e5289.
[24] "Army Training Network - Standard METL," April 7, 2019, https://atn.army.mil/ATNPortalUI/METL/.
[25] "Army Trainign Network - Combined Arms Training Strategy."
[26] "Army Trainign Network - Combined Arms Training Strategy."
[27] "Conduct an Attack - Rifle Company (IBCT)" (Fort Benning, GA: Maneuver Center of Excellence, February 19, 2019), 8.
[28] "Army Trainign Network - Combined Arms Training Strategy," 14.
[29] "Virtual Battlespace Data Sheet," Data Sheet (Bohemia Interactive Simulations, 2018), https://bisimulations.com/sites/default/files/data_sheets/bisim_product_flyers_nov2018_vbs3_us_1.pdf.
[30] "Virtual Battlespace Data Sheet."
[31] Faisal Rashid, "Use of VR Technology and Passive Haptics for MANPADS Training System" (Thesis, Naval Postgraduate School, 2017), 20, Calhoun, http://hdl.handle.net/10945/56170.
[32] Rashid, 21.
[33] Rashid, 22.
[34] James Templeman, Robert Page, and Patricia Denbrook, "10 Avatar Control in Virtual Environments," 2014, 237, https://www.researchgate.net/profile/James_Templeman/publication/265683587_Avatar_Control_in_Virtual_Environments/links/57ac811508ae7a6420c2ecfa/Avatar-Control-in-Virtual-Environments.pdf.
[35] "VR Arcade - Virtual Reality Games | Main Event," Main Event Entertainment, accessed May 30, 2019, https://www.mainevent.com/play/v-play-reality.
[36] Templeman, Page, and Denbrook, "10 Avatar Control in Virtual Environments," 240.
[37] Rashid, "Use of VR Technology and Passive Haptics for MANPADS Training System," 23.
[38] Rashid, 25.
[39] Templeman, Page, and Denbrook, "10 Avatar Control in Virtual Environments," 252.