2022-09

ENVISIONING BETTER POLICE PERFORMANCE WITH SELECTIVE-FIDELITY TRAINING: LESSONS FROM SIMULATIONS AND VIRTUAL REALITY IN AVIATION AND MEDICINE

Espy, Thaddeus

Monterey, CA; Naval Postgraduate School

https://hdl.handle.net/10945/71007

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

ENVISIONING BETTER POLICE PERFORMANCE WITH SELECTIVE-FIDELITY TRAINING: LESSONS FROM SIMULATIONS AND VIRTUAL REALITY IN AVIATION AND MEDICINE

by

Thaddeus Espy

September 2022

Thesis Advisor: Rodrigo Nieto-Gomez
Second Reader: John W. Rollins (contractor)

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** September 2022	**3. REPORT TYPE AND DATES COVERED** Master's thesis	
4. TITLE AND SUBTITLE ENVISIONING BETTER POLICE PERFORMANCE WITH SELECTIVE-FIDELITY TRAINING: LESSONS FROM SIMULATIONS AND VIRTUAL REALITY IN AVIATION AND MEDICINE			**5. FUNDING NUMBERS**
6. AUTHOR(S) Thaddeus Espy			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

This thesis explores how technology-based, selective-fidelity training methods found in aviation and medicine can improve law enforcement training and performance. Professionals in aviation, medicine, and law enforcement all encounter high-risk and unpredictable situations. Within aviation and medicine, research has shown that simulation and virtual reality (VR) can improve performance at all levels—from beginner to advanced. This thesis reviews Bloom's taxonomy, state- and context-dependent learning, and law enforcement training practices; assesses the efficacy of selective-training methods across the aviation and medical fields; and reviews real-world applications of simulation and VR. This research determined that certain technology-based, selective-fidelity training methods found in aviation and medicine may improve law enforcement training and performance. To best leverage simulation and VR, the law enforcement community should match the device's fidelity (high or low) to the underlying learning objective; utilize both high- and low-fidelity training methods confidently; and mimic the medical sector's standard, policy, and procedure development for technology-based, selective-fidelity training methods. Also, high-fidelity training methods may improve performance in novel situations. Finally, law enforcement trainers should use certain devices to mitigate stress, treat post-traumatic stress disorder, teach checklist material, and promote confidence.

14. SUBJECT TERMS law enforcement, military, aviation, medical, training, simulator, simulation, reality-based, training, efficacy, basic academy, augmented reality, virtual reality, VR, high-risk, development, high-fidelity, selective-fidelity, computer-based			**15. NUMBER OF PAGES** 113
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

ENVISIONING BETTER POLICE PERFORMANCE WITH SELECTIVE-FIDELITY TRAINING: LESSONS FROM SIMULATIONS AND VIRTUAL REALITY IN AVIATION AND MEDICINE

Thaddeus Espy
Major, City of Tulsa, Tulsa Police Department
BS, University of California, Davis, 1996
MA, University of San Francisco, 2003

Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF ARTS IN SECURITY STUDIES
(HOMELAND SECURITY AND DEFENSE)**

from the

**NAVAL POSTGRADUATE SCHOOL
September 2022**

Approved by: Rodrigo Nieto-Gomez
Advisor

John W. Rollins
Second Reader

Erik J. Dahl
Associate Professor, Department of National Security Affairs

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

This thesis explores how technology-based, selective-fidelity training methods found in aviation and medicine can improve law enforcement training and performance. Professionals in aviation, medicine, and law enforcement all encounter high-risk and unpredictable situations. Within aviation and medicine, research has shown that simulation and virtual reality (VR) can improve performance at all levels—from beginner to advanced. This thesis reviews Bloom's taxonomy, state- and context-dependent learning, and law enforcement training practices; assesses the efficacy of selective-training methods across the aviation and medical fields; and reviews real-world applications of simulation and VR. This research determined that certain technology-based, selective-fidelity training methods found in aviation and medicine may improve law enforcement training and performance. To best leverage simulation and VR, the law enforcement community should match the device's fidelity (high or low) to the underlying learning objective; utilize both high- and low-fidelity training methods confidently; and mimic the medical sector's standard, policy, and procedure development for technology-based, selective-fidelity training methods. Also, high-fidelity training methods may improve performance in novel situations. Finally, law enforcement trainers should use certain devices to mitigate stress, treat post-traumatic stress disorder, teach checklist material, and promote confidence.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

ACS	American College of Surgeons
ALICE	Artificial Interface for Clinical Education
CBT	cognitive behavioral therapy
ENT	ear, nose, and throat (specialist)
EVA	extravehicular activity
FAA	Federal Aviation Administration
FTO	field training officer
FSTD	flight-simulator training device
INACSL	International Nursing Association for Clinical Simulation and Learning
NASA	National Aeronautics and Space Administration
NCCMMS	National Center for Collaboration in Medical Modeling and Simulation
NSS	naval standard score
OSCE	Objective Structured Clinical Examination
PSNS	parasympathetic nervous system
PTSD	post-traumatic stress disorder
RBT	reality-based training
SAFER	simplified aid of EVA rescue
SNS	sympathetic nervous system
SSH	Society for Simulation in Healthcare
VFR	visual flight rules
VR	virtual reality
VRET	virtual reality exposure treatment

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

Law enforcement training comprises many traditional methodologies, yet research shows that innovative methods like experiential learning can improve performance.[1] Technology-based, selective-fidelity training methods found in aviation and medicine, such as simulation and virtual reality (VR), provide experiential learning opportunities that enhance training and performance.[2] This study found that these training methods have the potential to improve law enforcement training and performance.

Based on the findings of this research study, the law enforcement community can best leverage simulation and VR by matching a device's fidelity (high or low) to the underlying learning objective (upper- or lower-order learning), utilizing both high- and low-fidelity training methods confidently and mimicking the medical sector's system of developing standards, policies, and procedures surrounding technology-based, selective-fidelity training methods.

This thesis employed a mixed-methods research approach.[3] Previously, researchers had not directly compared the applicability of technology-based, selective-fidelity training methods in the target fields—aviation and medicine—to law enforcement. However, numerous researchers have studied the efficacy of technology-based, selective-fidelity

[1] Northern Illinois University Center for Innovative Teaching and Learning, "Experiential Learning," in *Instructional Guide for University Faculty and Teaching Assistants* (DeKalb: Northern Illinois University, 2012), https://www.niu.edu/citl/resources/guides/instructional-guide/experiential-learning.shtml.

[2] Ioana Koglbauer, "Simulator Training Improves Pilots' Procedural Memory and Generalization of Behavior in Critical Flight Situations," *Cognition, Brain, Behavior* 20, no. 4 (December 2016); Robert Kleinert et al., "Web-Based Immersive Virtual Patient Simulators: Positive Effect on Clinical Reasoning in Medical Education," *Journal of Medical Internet Research* 17, no. 11 (November 2015): e263, https://doi.org/10.2196/jmir.5035.

[3] Judith Schoonenboom and R. Burke Johnson, "How to Construct a Mixed Methods Research Design," *Kölner Zeitschrift für Soziologie und Sozialpsychologie* 69, no. Suppl. 2 (2017): 107–31, https://doi.org/10.1007/s11577-017-0454-1.

training methods in aviation and medicine.[4] Thus, this thesis reviewed a selection of those studies, focusing on the general efficacy of technology-based, selective-fidelity training methods and their applicability in developing certain skills found in some law enforcement encounters. Finally, this study reviewed a small sample of successful applications across the target sectors while highlighting relevant points for law enforcement training and performance.[5]

According to the analysis conducted in this thesis, many opportunities exist for the law enforcement training community. Law enforcement trainers should confidently employ a wide range of methods, spanning tablet-based games to immersive VR devices, because researchers have found that both ends of the fidelity spectrum can be efficacious at developing performance. Research shows that more-sophisticated options like VR devices and advanced simulators can better develop higher-order learning, so law enforcement trainers should incorporate high-fidelity training options when inculcating advanced learning objectives.[6] Researchers in aviation and medicine have also determined that these methods are effective at developing stress management skills as well as assisting in post-traumatic stress disorder treatment.[7]

---

[4] Koglbauer, "Simulator Training Improves Pilots' Procedural Memory"; Christopher K. McClernon et al., "Stress Training Improves Performance during a Stressful Flight," *Human Factors: Journal of the Human Factors and Ergonomics Society* 53, no. 3 (June 2011): 207–18, https://doi.org/10.1177/0018 720811405317; Guillaume Alinier, "A Typology of Educationally Focused Medical Simulation Tools," *Medical Teacher* 29, no. 8 (January 2007): e243–50, https://doi.org/10.1080/01421590701551185.

[5] Inc., "Captain Sully's Minute-by-Minute Description of the Miracle on the Hudson," March 6, 2019, YouTube video, 12:22, https://www.youtube.com/watch?v=w6EblErBJqw; Sung-Hee Han et al., "Effect of Immersive Virtual Reality Education before Chest Radiography on Anxiety and Distress among Pediatric Patients: A Randomized Clinical Trial," *JAMA Pediatrics* 173, no. 11 (2019): 1026, https://doi.org/10. 1001/jamapediatrics.2019.3000; L. V. Eshuis et al., "Efficacy of Immersive PTSD Treatments: A Systematic Review of Virtual and Augmented Reality Exposure Therapy and a Meta-Analysis of Virtual Reality Exposure Therapy," *Journal of Psychiatric Research* 143 (November 2021): 516–27, https://doi. org/10.1016/j.jpsychires.2020.11.030.

[6] Aaron Judy and Thomas Gollery, "U.S. Navy Pilot Competence: An Exploratory Study of Flight Simulation Training versus Actual Aircraft Training," *Journal of Applied Social Science Research and* Practice 1 (2019): 4–33.

[7] McClernon, Christopher K., Michael E. McCauley, Paul E. O'Connor, and Joel S. Warm. "Stress Training Improves Performance During a Stressful Flight." *Human Factors: Journal of the Human Factors and Ergonomics Society* 53, no. 3 (June 2011): 207–18. https://doi.org/10.1177/0018720811405317.

Moreover, law enforcement trainers should use high-fidelity training methods as bridges to the most realistic training options—such as reality-based training with its real-life scenarios, live role players, and projectile-based weapons—because research shows that the most-advanced students require realistic experiences to develop their skills.[8] Aviation and medical researchers have found that real-world training is more effective than simulated training environments once students reach a certain proficiency level—experience trumps even highly realistic simulated experience.[9]

However, lower-fidelity devices should also play an integral role in the training and development of police officers. Low-fidelity training options are especially beneficial regarding lower-order learning and stewardship of resources. Research indicates that lower-fidelity devices can effectively develop information acquisition and recall, and these devices are less costly than high-fidelity devices.[10] Thus, law enforcement trainers should utilize low-cost phone- or tablet-based games to inculcate rote information like basic academy education, laws, and policies and procedures.

Interestingly, the academic research and real-world events indicate that simulated training can better prepare police officers for novel situations. The law enforcement profession consists of encounters involving unpredictability, information deficiency, and complexity, so law enforcement trainers cannot duplicate every encounter in the learning environment—time, money, and resources are limited. The benefit of simulated training is twofold: it prepares police officers for conceivable encounters and helps to develop intuitive skills to cope with inconceivable circumstances. The latter can be inherently stressful, thus inhibiting creative thought, yet high-fidelity simulated training can help police officers build a toolbox of complex problem-solving skills and stress management techniques that lead to inventive solutions and improved performance during novel situations.

---

[8] Judy and Gollery, "U.S. Navy Pilot Competence."

[9] Judy and Gollery.

[10] Guillaume Alinier, "A Typology of Educationally Focused Medical Simulation Tools," *Medical Teacher* 29, no. 8 (January 2007): e243–50. https://doi.org/10.1080/01421590701551185.

Additionally, research shows that deliberate breath control, refined focus, and controlled attention in combination with simulated training may improve performance in stressful situations.[11] Therefore, law enforcement trainers should aim to incorporate these practices through technology-based, selective-fidelity training methods, particularly when developing higher-order skills during simulator and VR training. Also, the law enforcement training community should seek to enhance confidence with technology-based, selective-fidelity training methods because research shows that even low-fidelity training methods can develop the knowledge of what to do and the confidence to do it.

Furthermore, based on the analysis of this research, the law enforcement training community should pursue a system for establishing standards, policies, and procedures surrounding the use of technology-based, selective-fidelity training methods similar to those utilized in the medical industry.[12] This recommendation stems from a commonality between the medical and law enforcement sectors: decentralization. Within the medical sector's decentralized system, certain organizations have emerged as industry-wide leaders in establishing standards, policies, and procedures. Similarly, many law enforcement organizations provide policy and strategic recommendations to the law enforcement profession, including the International Association of Chiefs of Police, the Major City Chiefs Association, the Police Executive Research Forum, the International Law Enforcement Educators and Trainers Association, and the International Association of Directors of Law Enforcement Standards and Training.[13] These organizations could also provide industry-wide recommendations on the standards, policies, and procedures surrounding the use of technology-based, selective-fidelity training methods in law enforcement training.

---

[11] McClernon et al., "Stress Training Improves Performance."

[12] This claim is established and developed in the body of this thesis.

[13] "Home Page," International Association of Chiefs of Police, accessed September 14, 2022, https://www.theiacp.org/; "Home Page," Major Cities Chiefs Association, accessed September 14, 2022, https://majorcitieschiefs.com/; "Home Page," Police Executive Research Forum, accessed September 14, 2022, https://www.policeforum.org/; "Home Page," International Association of Directors of Law Enforcement Standards and Training, accessed September 14, 2022, https://www.iadlest.org/.

Future research could include an exploration of effective curriculum design or an analysis of the efficacy of devices currently in the marketplace. Curriculum design can be instrumental in the effectiveness of an education program, so research in this area focused on technology-based, selective-fidelity training methods might yield more effective curricula. In addition, the technology-based, selective-fidelity training marketplace consists of numerous simulators and VR devices, research examining the efficacy of particular devices in use could help police trainers select the best devices and promote responsible stewardship of limited public resources.

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

I would like to acknowledge a few people who supported and assisted me through this master's degree program and thesis. First, and foremost, I would like to thank my wife, Shannon, and my children, Atlas and Ryan, for their daily support. Their positivity was unwavering, and their sacrifices did not go unnoticed. Without them, I would not have crossed the finish line. I look forward to more time together. Next, I would like to thank my thesis advisor, Rodrigo Nieto-Gómez, and second reader, John Rollins. Finally, I would like to express my thanks to Daniel Lehnherr of the Naval Postgraduate School's Graduate Writing Center. I appreciate his ongoing feedback, critical eye, and support as I completed this thesis.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

Training is a valuable tool for improving human performance. However, not all training is the same. The phrase "perfect practice makes perfect" illustrates how proper curriculum design and implementation can result in more effective training and enhance performance. Moreover, the effective use of training aids can enhance training programs. This research study is interested in finding better training devices and methods for law enforcement professionals.

Technology advancements have increased the use of various technology-based, selective-fidelity training methods in many fields. Most commonly, these methods involve simulators and virtual reality (VR) devices. Two fields that have strongly leveraged the use of these training methods are aviation and medicine. For example, aviation and medicine utilize simulation and VR training devices in initial and continuing education.[1] The law enforcement training community is also interested in applying these training tools. Consequently, law enforcement might have something to learn from aviation and medicine.

A. RESEARCH QUESTION

This thesis seeks to answer the following question: How can technology-based, selective-fidelity training devices, methods, procedures, and standards found in the aviation and medical sectors improve law enforcement training and, ultimately, police performance? The answer is important for both individuals and society. On the individual level, more effective training can improve safety for law enforcement officers and citizens. On a larger scale, enhanced training and better performance might reduce controversy surrounding some police encounters, decrease mistrust of law enforcement, and improve community relations.

---

[1] "FAA Approved Aviation Training Devices (ATDs)," Federal Aviation Administration, May 28, 2021, https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs800/afs810/media/FAA_Approved_Airplane_ATDs.pdf; Amanda Henry, "A Brief History of Simulation Training," Industrial Training International, January 18, 2018, https://www.iti.com/blog/a-brief-history-of-simulation-training-.

B. PROBLEM STATEMENT

The law enforcement profession is challenging for many reasons. Every day, police officers face the risk of injury or death; they often lack pertinent information when responding to calls for service; they must make split-second decisions. However, training officers for these challenges is difficult, too.

Typically, police training begins with the basic academy, a multi-month training program that covers dozens of distinct learning domains. After the basic academy, rookie police officers complete months of on-the-job training, also known as field training. Additionally, many states require mandatory annual continuing education, commonly called in-service training.[2]

The most significant challenge police educators and trainers face during the basic academy or in-service training is replicating the real world in the academic setting. Real-world conditions are complicated, complex, unpredictable, and chaotic, so at best, law enforcement educators can only partially recreate reality in training. Yet, studies indicate that the closer the learning environment matches the performance environment, the better people will perform in real life.[3] Thus, for police, this means that the better trainers duplicate real-world conditions in training environments, the better officers will perform in the real world.

Commonly, law enforcement trainers employ experiential learning opportunities like practical exercises, role-playing, and reality-based training scenarios to bridge the gap between reality and the academic setting. These experiential methodologies are beneficial but require extensive resources—multiple instructors, in-depth instructor development, expensive equipment, and involved safety protocols—which limit their use.[4] However, technology, specifically simulation and VR, is very effective at creating immersive

---

[2] Emily D. Buehler, *State and Local Law Enforcement Training Academies, 2018—Statistical Tables*, NCJ 255915 (Washington, DC: Bureau of Justice Statistics, 2021).

[3] Saul McLeod, "Context and State Dependent Memory," Simply Psychology, 2021, https://www.simplypsychology.org/context-and-state-dependent-memory.html.

[4] The claims in this paragraph, as with many other statements of fact through this thesis, are based on the author's professional experience, training, and education, including over 15 years of law enforcement, military, and civilian training in multiple force-related disciplines.

environments that can bridge the gap between reality and the academic setting. Moreover, simulation and VR training can be less costly, simpler to use, and less risky than other experiential learning techniques currently used in law enforcement.[5]

This is not theoretical. This research study is motivated by the U.S. aviation and medical sectors. These fields have innovated and incorporated simulation and VR into their training programs to enhance human performance. Not only have these fields used such modalities to develop knowledge, skills, and abilities, but in some cases, they have used these methods to bring standards and uniformity to their training.[6] Also interesting is how aviation and medicine use simulation and VR to address the same problems that police officers face: risk of injury and death, information-deficient conditions, and critical decision-making.

C. RESEARCH DESIGN

Ultimately, this thesis seeks to understand how simulation and VR training methods, procedures, and standards found in the aviation and medical sectors might improve law enforcement training and, ultimately, police performance. This thesis employs a mixed-methods research approach to achieve this goal.

Research studies that directly compare the applicability of technology-based, selective-fidelity training methods between law enforcement and the target fields—aviation and medicine—would be highly insightful, but researchers have not conducted such studies. However, numerous researchers have studied the efficacy of technology-based, selective-fidelity training methods in aviation and medicine.[7] Consequently, this

[5] Robert Kleinert et al., "Web-Based Immersive Virtual Patient Simulators: Positive Effect on Clinical Reasoning in Medical Education," *Journal of Medical Internet Research* 17, no. 11 (November 2015): e263, https://doi.org/10.2196/jmir.5035.

[6] "National Simulator Program (NSP)," Federal Aviation Administration, accessed August 25, 2022, https://www.faa.gov/about/initiatives/nsp/.

[7] Ioana Koglbauer, "Simulator Training Improves Pilots' Procedural Memory and Generalization of Behavior in Critical Flight Situations," *Cognition, Brain, Behavior* 20, no. 4 (December 2016); Christopher K. McClernon et al., "Stress Training Improves Performance during a Stressful Flight," *Human Factors: Journal of the Human Factors and Ergonomics Society* 53, no. 3 (June 2011): 207–18, https://doi.org/10.1177/0018720811405317; Guillaume Alinier, "A Typology of Educationally Focused Medical Simulation Tools," *Medical Teacher* 29, no. 8 (January 2007): e243–50, https://doi.org/10.1080/01421590701551185.

study first reviews a selection of those studies. The review focuses on the general efficacy of technology-based, selective-fidelity training devices and particular methods for improving performance necessary in law enforcement, for example, enhancing stress mitigation skills and developing lower-order versus higher-order learning objectives.

Often, industry-wide standards support consistency across organizations. To varying degrees, the aviation and medical sectors have standardized the devices, policies, and procedures surrounding technology-based, selective-fidelity training methods. Ostensibly, this uniformity has improved training consistency, better shared lessons learned, and ultimately, enhanced performance. Thus, reviewing the conceptual underpinnings and practical applications of aviation's and medicine's standards, policies, and procedures also benefits this research study.

Finally, researchers and journalists have highlighted success stories surrounding the application of technology-based, selective-fidelity training methods in aviation and medicine.[8] Some techniques have improved training outcomes while others have saved lives in real-world situations.[9] Therefore, this study reviews a small sample of successful applications across those sectors and highlights significant points relevant to law enforcement training and performance.

It is beyond the scope of this study to review every aspect and component of all technology-based, selective-fidelity training devices and methods in each target sector, so once again, this thesis strives to select relevant, insightful studies with bearing on law enforcement training.

D. LITERATURE REVIEW

This literature review focuses on learning theory, teaching methods, some types of technology-based training methods and their efficacy, and the current landscape of law enforcement training and education. Furthermore, the literature review defines terms and

[8] Inc., "Captain Sully's Minute-by-Minute Description of the Miracle on the Hudson," March 6, 2019, YouTube video, 12:22, https://www.youtube.com/watch?v=w6EblErBJqw.

[9] Inc.

provides a foundational understanding of selective-fidelity training methods. Currently, cross-disciplinary research into the applicability or transferability of selective-fidelity training methods between the target fields is limited. Thus, the aim here is to provide the foundation for analyzing the potential applicability or transferability of technology-based, selective-fidelity training devices and methods between aviation, medicine, and law enforcement.

1. Bloom's Taxonomy

In later chapters, this thesis evaluates the effectiveness of learning methods; consequently, a framework is necessary for those assessments. Although different learning systems exist within education, this study uses Bloom's taxonomy as a framework for understanding, assessing, and evaluating those training methods because of its popularity and established benefits. For decades, many fields have relied on Bloom's taxonomy. According to Lovell-Troy, Bloom's taxonomy is "the most widely used classification system for cognitive, educational objectives."[10] In addition, as Lasley articulates, "Bloom's taxonomy engendered a way to align educational goals, curricula, and assessments that are used in schools, and it structured the breadth and depth of instructional activities and curriculum that teachers provide for students."[11] Thus, in general, this system provides a sense-making framework for understanding and evaluating educational modalities, specifically, in this case, the potential merits of technology-based, selective-fidelity training methods.

Bloom's taxonomy is the product of the collaborative work of researchers Benjamin Bloom, Max Englehart, Edward Furst, Walter Hill, and David Krathwohl in the 1956 *Taxonomy of Educational Objectives*.[12] In 2001, a group of educational specialists revised Bloom's taxonomy. Figure 1 depicts the revised framework's six hierarchical categories

[10] Larry A. Lovell-Troy, "Teaching Techniques for Instructional Goals: A Partial Review of the Literature," *Teaching Sociology* 17, no. 1 (January 1989): 28, https://doi.org/10.2307/1317922.

[11] Thomas J. Lasley, s.v. "Bloom's taxonomy," *Encyclopedia Britannica*, accessed August 24, 2022, para. 1, https://www.britannica.com/topic/Blooms-taxonomy.

[12] Patricia Armstrong, "Bloom's Taxonomy," Vanderbilt University, 2010, https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/.

that begin with *remember*; move through *understand*, *apply*, *analyze*, and *evaluate*; and peak with *create*.[13]

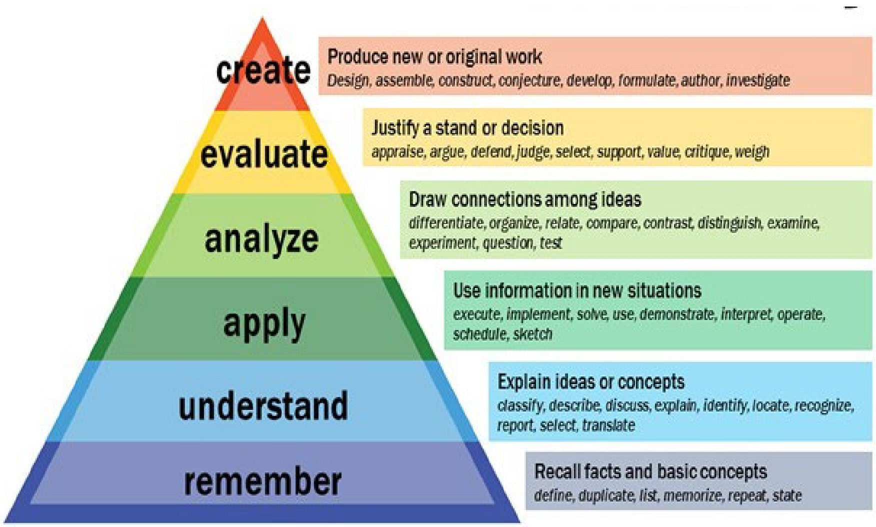

Figure 1. Bloom's Taxonomy[14]

Each level is relevant to police officer training and development. Beginning with *remember* and *understand*, which relate to essential information, police must recall (remember) basic information from memory—laws and department policies—and understand basic legal concepts—probable cause and reasonable suspicion—to graduate from the academy. Effective law enforcement also requires that police officers understand these legal concepts when they detain citizens (reasonable suspicion) or seize property (probable cause).

Next, the *apply* level involves the "use of information in new situations," according to Armstrong.[15] In practice, applying may relate to using memorized information and fundamentally understanding situations not covered in the classroom. Novel situations are not unusual in police work, so developing effective performance at the *apply* level is

[13] Armstrong.

[14] Source: Armstrong.

[15] Armstrong.

imperative for sound police work. When police officers operate at the *analyze* level, they deal with situations that "draw connections among ideas."[16] For example, in finding solutions to information-deficient situations, police officers must "differentiate, relate, compare, and question."[17]

Ascending the hierarchy, the next step is to *evaluate*, which Armstrong describes as the ability to "justify a stand or decision."[18] Within law enforcement, some situations thrust officers into extreme decision-making situations. For example, in use-of-force encounters, officers may have mere seconds to critique the totality of the circumstance, select an appropriate force option, and weigh the reasonableness of their potential actions.[19]

Finally, the pinnacle of Bloom's taxonomy is to *create*, a learning level crucial for police in tackling the challenges they face. For example, before depriving someone of liberty (i.e., making an arrest), police investigate situations, formulate probable cause, and author affidavits attesting to gathering facts.

2. Memory

Memory plays a significant role in learning, so a brief exploration and explanation of memories should benefit this study. Based on the seminal work of Ricard Semon nearly 100 years ago, biologists, neurologists, and psychologists now better understand memory. Semon studied memory and developed the concept of "engrams," or the physical manifestation of memories.[20] According to Semon, engrams were "the residues or traces of prior stimulation that, once re-activated in irritable tissue, enabled past excitation to change an organism's reaction to new stimulation."[21] Over the years, researchers have

---

[16] Armstrong.

[17] Armstrong.

[18] Armstrong.

[19] Armstrong.

[20] Cheryl A. Logan, "Engrams and Biological Regulation: What Was 'Wrong' with Organic Memory?," *Memory Studies* 8, no. 4 (October 2015): 407–21, https://doi.org/10.1177/1750698015575189.

[21] Logan, 412.

built on Semon's work, and today, some researchers believe engrams are brain cells—or the "neural substrate for storing and recalling memories"—encoded with information.[22] In addition, researchers have divided encoded data stored in the brain into short-term or long-term constructs.[23] Finally, retrieval is the process of recalling information or memories.[24]

3. State-Dependent and Context-Dependent Learning

Research has shown that the closer the learning environment matches the performance environment, the better the performance. Furthermore, learning is the result of many interconnected variables. Two critical variables are state- and context-dependent learning. State-dependent learning refers to an individual's affective or emotional state, and context-dependent learning refers to the learning environment. Both play a role in education and affect the connection between the learning environment and real-world conditions.

a. State-Dependent Learning

Researchers in various fields have studied state-dependent learning, and although slightly different definitions exist, they all share common themes or threads. According to Saul McLeod, "State-dependent memory refers to improved recall of specific episodes or information when cues relating to [the] emotional and physical state are the same during encoding and the retrieval."[25] This definition is supported by Relias and Rockhold's discussion on the matter, which offers that in state-dependent learning, individuals' internal feelings or states of awareness at the times of encoding and retrieval affect their ability to access memories.[26] Finally, Tyng et al. highlight the importance of a student's affective

[22] Sheena A. Josselyn and Susumu Tonegawa, "Memory Engrams: Recalling the Past and Imagining the Future," *Science* 367, no. 6473 (2020): 1, https://doi.org/10.1126/science.aaw4325.

[23] Trudi Radtke, ed., *Cognitive Psychology* (Santa Clarita, CA: College of the Canyons, n.d.).

[24] Radtke.

[25] McLeod.

[26] Nina Relias and Madeline Rockhold, "Stress Well to Test Well? How Applying State Dependent Learning Can Lead to Better Test Results," *Only Human 2.0* (blog), April 30, 2017, https://onlyhuman2.swanpsych.com/2017/04/30/stress-well-to-test-well-how-applying-state-dependent-learning-can-lead-to-better-test-results/.

disposition (emotional state), as it influences learning, memory, reasoning, and problem-solving.[27] Thus, state-dependent learning refers to internal influences, or the individual's condition, on the learning environment's cognitive processes, which affect how the information is encoded and how the individual accesses that information in the performance environment.

b. Implications for Law Enforcement Training

During their work, police officers experience potent emotions. In extreme situations, heightened emotions arouse the sympathetic nervous system (SNS), producing physiological effects and perceptual distortions.[28] Many recognize this phenomenon as the "fight, flight or freeze response."[29] The activation of the SNS is normal and causes, in part, physiological effects such as an increased heart rate and respiration, iris radial muscle contraction, and decreased stomach and intestine mobility.[30] These physiological effects can result in other phenomena—auditory exclusion, tunnel vision, and memory loss—that can impede police performance, sometimes with deadly consequences.[31] Consequently, police trainers seek to address SNS activation in two ways, both of which attempt to normalize the learning environment with the performance environment.

First, police trainers understand that activating the parasympathetic nervous system (PSNS) counteracts the effects of the SNS. Often, police officers can activate the PSNS simply by deep, deliberate, controlled breathing, sometimes referred to as "tactical breathing." This basic breathing exercise is a proven method to relax the SNS, improve

[27] Chai M. Tyng et al., "The Influences of Emotion on Learning and Memory," *Frontiers in Psychology* 8 (August 2017): 1454, https://doi.org/10.3389/fpsyg.2017.01454.

[28] Alexis Artwohl, "Perceptual and Memory Distortions during Officer Involved Shootings" (Skokie, IL: Americans for Effective Law Enforcement, 2008).

[29] Kirsten Nunez, "Fight, Flight, or Freeze: How We Respond to Threats," Heathline, February 21, 2020, https://www.healthline.com/health/mental-health/fight-flight-freeze.

[30] Josip Anđelo Borovac et al., "Sympathetic Nervous System Activation and Heart Failure: Current State of Evidence and the Pathophysiology in the Light of Novel Biomarkers," *World Journal of Cardiology* 12, no. 8 (August 2020): 373–408, https://doi.org/10.4330/wjc.v12.i8.373.

[31] Artwohl, "Perceptual and Memory Distortions."

cognition, and enhance performance.[32] Thus, law enforcement trainers deliberately incorporate tactical breathing into their instruction. In general, as depicted in Figure 2, peak performance is typically demonstrated at comparatively moderate arousal levels, so this first effort focuses on stabilizing and lowering the student's affective state.[33]

Second, law enforcement educators endeavor to create training experiences that increase students' arousal level but force them to perform even in the face of SNS effects. Police officers often face daunting situations, yet they must often act—fleeing or freezing are unacceptable responses. Thus, law enforcement trainers design these training iterations to overwhelm and stress police students, who may experience an activation of their SNS and adverse emotional reactions (e.g., anxiety, fear, and doubt). These police students cannot disengage or acquiesce; instead, they must act decisively to be successful.

---

[32] Jong W. Kim et al., "A Cognitive Modeling Approach—Does Tactical Breathing in a Psychomotor Task Influence Skill Development during Adaptive Instruction?," in *Augmented Cognition: Enhancing Cognition and Behavior in Complex Human Environments*, ed. Dylan D. Schmorrow and Cali M. Fidopiastis, Lecture Notes in Computer Science (Cham: Springer International Publishing, 2017), 162–74, https://doi.org/10.1007/978-3-319-58625-0_11.

[33] Ann Pietrangelo, "What the Yerkes-Dodson Law Says about Stress and Performance," Healthline, October 22, 2020, https://www.healthline.com/health/yerkes-dodson-law.

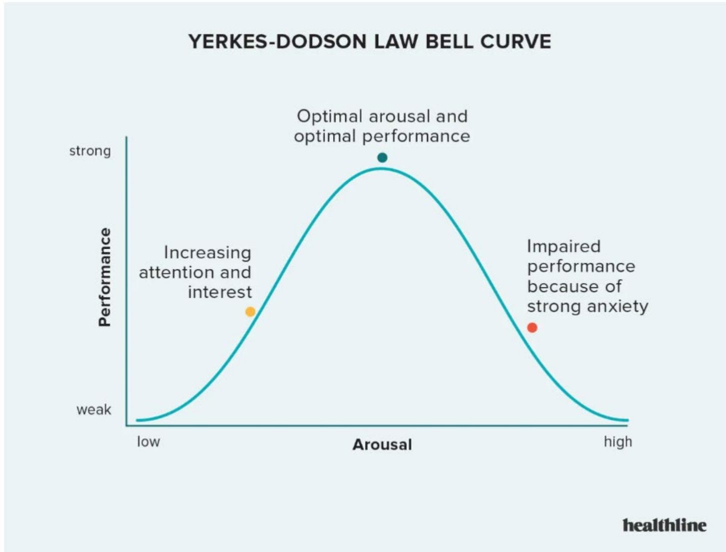

Figure 2. Yerkes-Dodson Law Bell Curve[34]

One of these real-world situations is an active-shooter incident. Plainly put, during such as encounter, police must act. Anything less is unforgivable in the eyes of many in our society. For example, in the aftermath of the 2018 active-shooter incident in Parkland, Florida, at Marjory Stoneman Douglas High School, the public and law enforcement community criticized numerous Broward County Sheriff's Office deputies, who had demonstrated a "neglect of duty."[35] Video footage captured these sheriff's deputies taking positions outside the school while a mass shooter killed 17 students.[36] The Florida Department of Law Enforcement's investigation found the dereliction of duty so egregious that it resulted in criminal charges against Deputy Scot Peterson.[37] As of 2022, Broward County prosecutors continue to seek a conviction on multiple charges against Scot

[34] Source: Pietrangelo.

[35] Chelsey Cox, "Fact Check: Officer Fired for Failing to Act during Parkland School Shooting Got His Job Back," *USA Today*, May 15, 2020, https://www.usatoday.com/story/news/factcheck/2020/05/15/fact-check-parkland-officer-who-failed-act-shooting-gets-job-back/5194831002/.

[36] Cox.

[37] Stacey Henson, "Former Parkland Deputy Scot Peterson Charged after Staying Outside Marjory Stoneman Douglas School Shooting," *USA Today*, June 4, 2019, https://www.usatoday.com/story/news/nation/2019/06/04/marjory-stoneman-douglas-resource-officer-charged-staying-outside-school-shooting/1343721001/.

Peterson, including "seven counts of child neglect, three counts of culpable negligence, and one count of perjury."[38]

Consequently, police trainers have developed a curriculum that helps students effectively act even in the face of significant SNS arousal. The Greek poet Archilochus stated, "We don't rise to the level of our expectations, we fall to the level of our training."[39] Agreeing with this apropos observation, many law enforcement instructors have developed progressively more difficult task requirements as training iterations unfold to build an effective default response system. For example, instructors may challenge the recruits' skills with an intentionally stressful test after engraining in them basic and intermediate arrest tactics and techniques. In one such test, a recruit may have to arrest a physically superior role player or deal with multiple assaultive role players. Students learn to default to their training and perform even with a strong emotional response, just as they must in a stressful real-world environment.

c. Context-Dependent Learning

Context-dependent learning is related to the students' learning environment. As with state-dependent learning, different researchers define context-dependent learning differently. Saul McLeod explains how it "refers to improved recall of specific episodes or information when contextual clues relating to the environment are the same during encoding and retrieval."[40] In their research on memory recall, Godden and Baddeley found that in accordance with context-dependent learning theory, information learned in one environment is best recalled in the same environment.[41] Trainers in the business sector

[38] Amanda Batchelor and Allison Cubillos, "Former BSO Deputy Scot Peterson Permitted to Visit Parkland School to Prepare for Trial," WPLG Miami, January 28, 2022, https://www.local10.com/news/local/2022/01/28/former-bso-deputy-scot-peterson-permitted-to-visit-parkland-school-to-prepare-for-trial/.

[39] "Archilochus Quotes," Goodreads, accessed August 24, 2022, https://www.goodreads.com/quotes/387614-we-don-t-rise-to-the-level-of-our-expectations-we; Alison Levy, "Performance Beyond Fitness: Conditioning, Nutrition, Sleep and Stress Mitigation Are All Key to Maximizing Performance," *Firehouse*, April 2017.

[40] McLeod.

[41] D. R. Godden and A. D. Baddeley, "Context-Dependent Memory in Two Natural Environments: On Land and Underwater," *British Journal of Psychology* 66, no. 3 (August 1975): 325–31, https://doi.org/10.1111/j.2044-8295.1975.tb01468.x.

have arrived at similar findings. Stephen Myer, founder and managing director of Rapid Learning, Inc., points out that students learn better if their training and performance environments are similar.[42]

d. Implications for Law Enforcement Training

Experienced military members, police trainers, and academics believe that better performance occurs when there is alignment or congruence between the learning environment and real-world conditions. For example, U.S. Army Lieutenant General Robert B. Brown opines, "Most importantly, the training environment must provide, to the fullest extent possible, representative human interactions, meaningful social-cultural situations, superior target engagements, and improved casualty assessments."[43] Ken Murray seconds this sentiment and recommends that law enforcement instructors use realistic settings, situations, and natural conclusions when designing curricula.[44] Finally, Wollert and Quail discuss the importance of matching the two environments: "Incorporating elements of realism . . . into the scenario design ensures the exposure will prepare students for real encounters."[45]

4. Selective Fidelity

Selective fidelity is the process of discriminating among and customizing specific state-dependent and context-dependent variables in training. Generally, fidelity refers to how precisely something is duplicated. Andrews, Carroll, and Bell believe that learning at its roots is related to the stimuli–response mechanism. Accordingly, selective fidelity is choosing a particular training system to elicit a specific learning outcome.[46]

---

[42] Stephen Meyer, "Context-Dependent Learning: How It Can Make Your Training Stick," *Rapid Learning* (blog), November 7, 2012, https://rapidlearninginstitute.com/blog/context-dependent-learning/.

[43] U.S. Army Combined Arms Center, *Enhancing Realistic Training: Delivering Training Capabilities for Operations in a Complex World* (Fort Leavenworth, KS: U.S. Army Combined Arms Center, 2016), ii.

[44] Kenneth R. Murray, *Training at the Speed of Life* (Gotha, FL: Armiger Publications, 2004).

[45] Terry N. Wollert and Jeff Quail, *A Scientific Approach to Reality Based Training* (Winnipeg: Three Pistols Publishing, 2018).

[46] Dee Howard Andrews, Lynn A. Carroll, and Herbert H. Bell, "The Future of Selective Fidelity in Training Devices," *Educational Technology* 35, no. 6 (1995): 32–36, https://www.jstor.org/stable/44428304.

Effective training must consider selective fidelity because no matter how much educators and trainers try, they can never duplicate every aspect of reality in the educational setting. In addition to the difficulties in reproducing the chaos and complexity of the real world, police trainers contend with limited budgets, time, and resources. Therefore, police trainers must make trade-offs and select only certain characteristics for their training. When done effectively, selective-fidelity training bridges the gap between learning and real-world environments, mirrors reality, and improves actual performance.

Both technology-based and non-technology-based, selective-fidelity training methods exist. Role-playing and reality-based training are examples of selective-fidelity training methods that do not rely heavily on technology—the latter uses relatively simple machines such as projectile-firing training aids. Primarily, these modalities rely on effective scenario design and realistic human interactions to create life-like interactions and training.

a. Technology-Based Selective Fidelity

Today, educators leverage technological advances to bridge the gap between the learning environment and reality to improve training. Specifically, simulation and VR are two prominent technology-based selective-training methods available.

Within the domain of technology-based, selective-fidelity training, common terminology and a baseline understanding do not readily exist. Different experts have defined technology-based selective fidelity in different ways. Schricker, Schricker, and Franceschini emphasize this disagreement by noting how "the concept of fidelity in a simulation model has become one of great contention among simulation researchers."[47] Various scholars, trainers, and technology manufacturers have worked to establish standards and commonly accepted definitions for technology-based, selective-fidelity training to build a common framework of understanding.

---

[47] Bradley C. Schricker, Stephen A. Schricker, and Robert W. Franceschini, "Considerations for Selective-Fidelity Simulation," in *Proceedings of the Society of Photo-Optical Instrumentation Engineers*, vol. 4367, *Enabling Technology for Simulation Science V*, ed. Alex F. Sisti and Dawn A. Trevisani (Orlando: Society of Photo-Optical Instrumentation Engineers, 2001), 62, https://doi.org/10.1117/12.440055.

For example, Andrews, Carroll, and Bell have developed a working definition of technology-based selective fidelity in their work on simulator efficacy. These studies focus on the stimuli–response relationship and describe selective fidelity as the process of choosing particular stimuli “that truly are necessary to perform the task.”[48] The scholars delineate fidelity into two primary categories: physical and functional.[49] Physical fidelity defines how closely a training device matches the machine it intends to represent while functional fidelity refers to a technology’s operational similarity to the device it represents.[50]

Research into a technology-based, selective-fidelity training alternative to the U.S. Army’s expensive, full-scale, motion-based helicopter simulators led Dennis Folds to develop a more nuanced definition of technology-based selective fidelity. Folds has recognized that the human–machine interface involves two types of fidelity that affect the experience: physical and behavioral.[51] Like Andrews, Carroll and Bell, Folds maintains that physical fidelity relates to the machine’s or device’s “comprehensiveness and realism.”[52] Furthermore, Folds has assessed physical fidelity by measuring a device’s ability to produce visual and auditory realism, match the layout and tactile feel of actual helicopters, and produce haptic feedback.[53] Haptics involves sensory responses in the form of “force, vibrotactile, electrotactile, ultrasound, and thermal feedback.”[54] In sum, definitions of physical fidelity by Folds and Andrews, Carroll, and Bell are similar.

However, Folds has further developed his definition of fidelity by including behavioral fidelity, which he divides into three categories: sensory, cognitive, and

[48] Andrews, Carroll, and Bell, 32.

[49] Andrews, Carroll, and Bell.

[50] Andrews, Carroll, and Bell.

[51] “Using Selective Fidelity in Immersive Learning Systems April 30, 2020,” Allen Interactions, streamed live on April 30, 2020, YouTube video, 56:10, https://www.youtube.com/watch?v=MMC1bYOykVk.

[52] Allen Interactions.

[53] Allen Interactions.

[54] “What is Haptic Feedback?,” *Teslasuit* (blog), accessed August 24, 2022, https://teslasuit.io/blog/haptic_feedback/.

psychomotor.[55] Within Folds's system, sensory fidelity overlaps slightly with physical fidelity particularly in how visual, auditory, and other sensory sensations are created in the learning environment compared to the "live environment."[56] Cognitive fidelity relates to the similarity of cognitive tasks, such as "remembering, calculating, comprehending, [and] deciding," between the learning environment and reality. Last, psychomotor fidelity relates to the correspondence of "gross and fine motor control" and "speech" output in the educational setting and reality.[57]

For this thesis, a universal definition is unnecessary, yet the varied perspectives provide a richer understanding. However, Folds's definition of fidelity includes elements related to a machine's fidelity (context-dependent variables) and the human perspective (state-dependent variables). Thus, Folds's paradigm may assist in analyzing how technology-based, selective-fidelity training methods in aviation and medicine might be applicable or transferable to law enforcement training.

b. Simulation

Simulation is a type of technology-based, selective-fidelity training method. Across aviation and medicine, trainers use simulators to develop various cognitive and psychomotor skills. Simulators offer several advantages over traditional training activities: time savings, cost reduction, and risk mitigation. Simulators take multiple forms, and the generic phrase "training simulator" often describes the entire universe of technology-based, selective-fidelity devices. However, different types and levels of fidelity—physical, functional, and behavioral—delineate a device's level of sophistication and define a particular device.

On one end of the spectrum, high-fidelity or highly sophisticated training simulators can be extremely elaborate and detailed, perfectly mimicking the real world—their gears and levers look just like the real thing. Furthermore, in the most-advanced

---

[55] Allen Interactions.

[56] Allen Interactions.

[57] Allen Interactions.

simulators, a student's mind is easily convinced that the simulated world is real because the student sees and hears—and maybe even feels and moves—as one does in real life. These simulators represent high physical, functional, and behavioral fidelity.

On the other end of the spectrum, low-fidelity training simulators bear almost no resemblance to the real world, functionally or physically. Many less-sophisticated training simulators require the students to pretend. Physically, low-fidelity training simulators do not look the same as the device they represent. For example, some military units have experimented with first-person shooter video games to develop firearms skills, but the video game controller bears no resemblance to an actual firearm.[58]

Some simulation includes a juxtaposition of fidelity elements. One well-known example is the PC-based game Microsoft Flight Simulator. Regarding physical and functional fidelity, although students can use replica yokes, throttles, and joysticks, the game's primary input devices are a keyboard and mouse, which are not representative of actual airplane controls. However, the software designers achieved incredible behavioral fidelity, closely mimicking a real aircraft's dynamics and performance. According to Asobo Studio founder and CEO Sebastian Wloch, "All [Microsoft Flight] aircraft have been reviewed with professional pilots who have many hours flying these aircraft or test pilots from the manufacturers to make sure they are controlled exactly as they should."[59] Thus, when viewed through the lens of Folds's paradigm, although the software maintains low physical and functional fidelity, it excels at behavioral fidelity, specifically cognitive fidelity.

c. Virtual Reality

Many consider VR the apex of immersive technology-based, selective-fidelity training devices. A universal definition of VR does not exist, but the definition developed by Cruz-Neira, Sandin, and DeFanti meets the aims of this thesis: "A VR system is one

[58] Karin A. Orvis et al., "Are Soldiers Gamers? Videogame Usage among Soldiers and Implications for the Effective Use of Serious Videogames for Military Training," *Military Psychology* 22, no. 2 (2010): 143–57, https://doi.org/10.1080/08995600903417225.

[59] Ed Darack, "How Did Microsoft Make Flight Simulator Seem So Real?, *Air & Space Magazine*, April 2021, https://www.airspacemag.com/flight-today/flight-box-180977303/.

which provides real-time viewer-centered head-tracking perspective with a large angle of view, interactive controls, and binocular display."[60] Some regard VR as a recent phenomenon, but the technology originated decades ago. In 1962, Morton Heilig created an advanced experience with his Sensorama device, which enhanced a prerecorded film with "binaural sound, scent, wind and vibration experiences."[61] By the 1990s, the term virtual reality had become mainstream.[62] In 1992, technologist Howard Rheingold noted, "Virtual reality is already a science, a technology, and business, supported by significant funding from the computer, communications, design, and entertainment industries worldwide."[63] Today, although the term is widespread and commonly used by many, VR is used interchangeably with such terms as virtual environments, synthetic experience, virtual worlds, artificial worlds, and artificial reality.[64] The adoption of VR technology has spread to private and public sectors, industries, and segments of society.

VR has become a business venture for some companies in the private sector. For example, according to Eric Savitz in a 2021 *Barron's* article, Facebook is interested in growing its VR offerings, the next being the Quest 2. During Facebook's fourth-quarter earnings meeting, CEO Mark Zuckerberg announced that the Quest 2 would become "the first mainstream virtual reality headset."[65] Savitz predicts Facebook will sell more than eight million Quest 2 devices and generate nearly "$2.4 billion, or 3% of Facebook's overall revenue."[66] These potential profits suggest that VR will remain a desirable business pursuit, which may lead to further technological developments.

---

[60] Carolina Cruz-Neira, Daniel J. Sandin, and Thomas A. DeFanti, "Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE," in *SIGGRAPH93: Proceedings of the 20st Annual Conference on Computer Graphics and Interactive Techniques* (New York: Association for Computing Machinery, 1993), 135, https://doi.org/10.1145/166117.166134.

[61] Tomasz Mazuryk and Michael Gervautz, "Virtual Reality: History, Applications, Technology and Future" (Vienna: Vienna University of Technology, 1999), 2.

[62] Mazuryk and Gervautz.

[63] Howard Rheingold, *Virtual Reality* (New York: Touchstone, 1992), 17.

[64] Mazuryk and Gervautz, "Virtual Reality," 3.

[65] Eric J. Savitz, "Facebook's VR Business Is Bigger Than You Think. And It Is Masking the Company's True Profitability," *Barron's*, June 28, 2021, https://www.barrons.com/articles/facebooks-vr-business-is-bigger-than-you-think-and-it-is-masking-the-companys-true-profitability-51624895223.

[66] Savitz.

While some firms seek to capitalize on the commercial and economic opportunities associated with VR, some public-sector organizations have leveraged the educational opportunities. For example, the National Aeronautics and Space Administration (NASA) uses VR in various ways. In 2020, NASA reported its use of VR to improve its understanding of the cosmos.[67] NASA scientists transitioned their analysis of the movement of stars in the Milky Way Galaxy from graph paper to a sophisticated VR simulator.[68] This transition resulted in a better understanding of how stars move and galaxies form and insights into star classification systems.[69] In another case, NASA uses VR to train astronauts how to leave the confines of the spaceship or venture out to complete repairs and conduct experiments, commonly called spacewalks or extravehicular activity (EVA), which can be risky.[70] At the Johnson Space Center, astronauts participate in NASA's VR training to build operational proficiency with the simplified aid of EVA rescue (SAFER) apparatus, which propels astronauts through spaces and allows the self-rescue of untethered astronauts.[71] The training is "immersive" and consists of "real-time graphics and motion simulators."[72] These improvements to skill development and performance indicate ways that the public sector may continue utilizing VR.

VR harbors incredibly transformative powers for the human experience. In his book *Virtual Reality*, Rheingold offers, "We are on the brink of having the power of creating any experience we desire" with VR.[73] Indeed, incredible technological advances in computer processors, computational speed, and network connectivity have launched VR into many

---

[67] Karl B. Hille, "Better than Reality: NASA Scientists Tap Virtual Reality to Make a Scientific Discovery," National Aeronautics and Space Administration, January 29, 2020, http://www.nasa.gov/feature/goddard/2020/scientists-tap-virtual-reality-for-discovery.

[68] Hille.

[69] Hille.

[70] Flint Wild, ed., "What Is a Spacewalk?," National Aeronautics and Space Administration, July 27, 2020, http://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-a-spacewalk-k4.html.

[71] "A Safer Way to Space Walk," National Aeronautics and Space Administration, February 27, 2004, https://www.nasa.gov/missions/shuttle/f_saferspacewalk.html; "How NASA Uses Virtual Reality to Train Astronauts," *Space Center Houston* (blog), September 25, 2018, https://spacecenter.org/how-nasa-uses-virtual-reality-to-train-astronauts/.

[72] "How NASA Uses Virtual Reality."

[73] Rheingold, *Virtual Reality*, 386.

sectors, industries, and fields.[74] In addition, researchers are working to understand how to leverage VR. For example, Kotler and Wheal are working to better understand how VR can create highly effective learning states and propel human performance to new levels.[75] According to these researchers, VR may aid in rapid language acquisition—a six-week language course might be possible in a fraction of that time.[76]

5. Current Law Enforcement Training and Education

A basic understanding of the current law enforcement training paradigm is essential. This section presents a general overview of the modern-day educational system for police, including initial basic academy training, field (on-the-job) training, and continuing education. A brief overview of the selective-fidelity training method in law enforcement follows. As a note, this overview is generalized because no one entity regulates the 18,000+ law enforcement agencies; thus, training programs in American law enforcement vary greatly.

Many federal, state, local, and tribal law enforcement agencies prepare police officers with significant education and training. First, agencies typically begin the education process with a basic academy, lasting anywhere from three to six months. According to the Department of Justice, the average basic academy lasts 833 hours (or just over five months).[77] The basic academy provides the educational underpinnings for police work, which generally focuses on the lower and intermediate levels of Bloom's taxonomy, including the remember and understand stages. Additionally, across the nation, in every academy, recruits participate in at least "one type of reality-based (mock) scenario during basic training."[78] This training provides recruits the opportunity to develop skills from the

---

[74] "Computers Are Becoming Faster and Faster, but Their Speed Is Still Limited by the Physical Restrictions of an Electron Moving through Matter. What Technologies Are Emerging to Break through This Speed Barrier?," *Scientific American*, October 21, 1999, https://www.scientificamerican.com/article/computers-are-becoming-fa/.

[75] Steven Kotler and Jamie Wheal, *Stealing Fire: How Silicon Valley, the Navy SEALS, and Maverick Scientists Are Revolutionizing the Way We Live and Work* (New York: Harper Collins, 2017).

[76] Kotler and Wheal.

[77] Buehler, *State and Local Law Enforcement Training Academies*.

[78] Buehler, 3.

intermediate and upper sections of Bloom's taxonomy—namely apply, analyze, evaluate, and create.

Upon completion of the basic academy, young police professionals commonly enter a field training officer (FTO) program. This program is essentially on-the-job training, whereby a series of senior officers, or FTOs, develop and mentor an apprentice police officer. Again, according to the Department of Justice, 83.4 percent of all police academies mandate field training, and on average, field training lasts 508 hours.[79] FTO training exposes apprentice police officers to intermediate and upper levels of learning in Bloom's taxonomy.

The basic academy and FTO program can sometimes last nearly a year. For example, the Tulsa Police Department in Oklahoma requires new police officers to complete a 29-week basic academy and 16-week field training officer program. These police officers complete 45 weeks of structured education and training before working alone.[80]

Finally, agencies supplement the basic academy and field training program with ongoing continuing education, or in-service training, throughout an officer's career. In-service training is not uniform across the nation. In 2017, a 42-state study conducted by the International Association of Directors of Law Enforcement Standards and Training and the Council of State Governments Justice Center determined that only 21 states had in-service training that ranged from 2 to 24 hours annually.[81] The in-service training curriculum can vary—some classes may provide a refresher of fundamental subject matter while others may present new challenging material.

[79] Buehler, 8.

[80] "Become a Tulsa Police Officer," Tulsa Police Department, accessed July 19, 2022, https://www.jointpd.com.

[81] International Association of Directors of Law Enforcement Standards and Training and Council of State Governments Justice Center, *The Variability in Law Enforcement State Standards: A 42-State Survey on Mental Health and Crisis De-escalation Training* (Eagle, ID: International Association of Directors of Law Enforcement Standards and Training, 2017).

a. Law Enforcement Use of Selective-Fidelity Training Methods

Currently, law enforcement utilizes various selective-fidelity training methods, and some involve technology. These methods are generally more interactive than traditional learning modalities (e.g., lectures and discussion) and provide an experiential learning opportunity for students. Experiential learning opportunities may be more appropriate for training police officers who deal with various challenging situations as they commonly include upper-tier learning objectives. Lovell-Troy supports this position, offering that "active-learning styles" best achieve Bloom's higher levels of learning.[82]

Examples of non-technology-based, selective-fidelity training methods include role-play and reality-based training. Reality-based training is high fidelity in terms of physical, functional, and behavioral fidelity. During reality-based training, role players realistically interact with police students in scenarios derived from actual police encounters. The role players portray suspects, victims, and bystanders with realism. These scenarios incorporate projectile-based training weapons, extensive protective equipment, and intensive in-role and post hoc coaching and feedback.

Reality-based training aims to expose students to a high level of realistic stimuli so that they develop appropriate responses. Ultimately, reality-based training aspires to develop in trainees the necessary physical skills to perform effectively in situations involving critical decision-making with compressed timeframes and limited information, the risk of injury or death, and dynamism and complexity. However, while many police departments incorporate reality-based training in their basic academies and continuing education, reality-based training requires significant resources (e.g., personnel, training, equipment, and safety protocols).[83]

b. Technology-Based, Selective-Fidelity Training Methods

The law enforcement training community has also utilized technology-based, selective-fidelity training methods to develop skills, most commonly for driving and

[82] Lovell-Troy, "Teaching Techniques for Instructional Goals."

[83] Buehler, *State and Local Law Enforcement Training Academies*.

firearms skill development. As early as 1973, the Los Angeles Police Department utilized a "computerized training facility" that employed "a huge concave motion picture screen" and firearms that fired "wax bullets."[84] The pitfall of this technology was the inability to have realistic interactions and develop decision-making skills. The "movie" unfolded in a predetermined script, regardless of how the student behaved with the on-screen actor. Even then, Los Angeles police trainers realized "almost anyone [could] learn how to shoot, in the classroom, and on the pistol range, but learning when to shoot [was] a lot more difficult, and a helluva lot more important."[85] Essentially, past technology lacked the necessary fidelity. This iteration's hardware and software limitations led to simplified, cartoonish environments and awkward, unnatural interactions with simulated role players. In turn, low fidelity resulted in suboptimal training. However, the landscape of technology-based, selective-fidelity training has changed.

Today, companies have leveraged technological advances to create sophisticated, full-immersion VR simulation devices for law enforcement trainers. Some machines offer superior physical, functional, and behavioral fidelity to their earlier counterparts. For example, the VR training device depicted in Figure 3 creates a highly realistic experience by placing the user in representative, intuitive, interactive virtual environments.[86] This training experience comprises a sophisticated virtual environment (physical fidelity) and improved interactions (behavioral fidelity). Furthermore, the software designers have created less rigid storylines, reducing awkward interactions and allowing students to react realistically and the training to follow a natural conclusion (behavioral fidelity).[87] In addition, many of the device's training aids—e.g., firearms and flashlights—are replicas of their real-world counterparts, thus elevating functional fidelity (physical fidelity).[88] In sum, devices such as these provide improved physical, functional, and behavioral fidelity

[84] Bill Hazlett, "LAPD Training Project: Police Know How to Shoot—When Is Now the Issue," *Los Angeles Times*, November 20, 1974.

[85] Hazlett.

[86] "VR Police Training Platform," Apex Officer, accessed August 25, 2022, https://www.apexofficer.com/platform.

[87] Apex Officer.

[88] Apex Officer.

and superior experiential learning opportunities compared to earlier iterations. Overall, based on their ability to provide an experiential learning opportunity, selective-fidelity training methods—involving technology or not—may be very beneficial for officers.

Figure 3. Technology-Based, Selective-Fidelity Training with VR Component[89]

c. Criticism of Law Enforcement Training

Some critics believe that current training methodologies fail to prepare police officers sufficiently for many of the profession's challenges. For example, the American Civil Liberties Union advocates a list of goals to improve policing, including enhanced training.[90] Similarly, in its Campaign Zero, WeTheProtestors, a national organization "focused on ending racism and police violence in America," calls for changes in police training to "effectively teach them how to interact with our communities in a way that protects and preserves life."[91] These community stakeholders are not alone in their demands for change.

[89] Source: Apex Officer, "VR Police Training Platform."

[90] American Civil Liberties Union, *Fighting Police Abuse: A Community Action Manual* (New York: American Civil Liberties Union, 1997), https://www.aclu.org/other/fighting-police-abuse-community-action-manual.

[91] "Training," Campaign Zero, accessed August 25, 2022, https://www.campaignzero.org/train.

Even the federal government and prominent police trainers have echoed the same message. In 2015, the President's Task Force on 21st Century Policing emphasized a need for "more effective training."[92] Ken Murray, an expert in police training, believes the current paradigm does not sufficiently prepare officers for the reality of the job since today's training does not efficiently develop decision-making and stress tolerance through experiential learning.[93] According to Murray, "Just because 'that's the way it's always been …' is insufficient reason to preserve the status quo of a law enforcement training program."[94]

The law enforcement training community should willingly consider this external and internal criticism and treat it as an opportunity to evaluate the quality of its education for several reasons. First, the criticism and concerns come from multiple sources. When varied perspectives arrive at a similar conclusion, it may indicate an accurate assessment from those respective sources. Second, law enforcement is a governmental entity and should be reflexive to the opinions of the governed. Such openness can improve relationships between those who govern and those governed. Finally, law enforcement encounters at times have deadly consequences for police officers and citizens. If training might enhance the quality of performance and potentially save lives, the law enforcement training community must assess opportunities to do so.

E. THESIS ROADMAP

Chapter II focuses on aviation, reviewing 1) the use of simulation and VR training devices; 2) the efficacy of training devices; 3) standards, policies, and procedures surrounding training devices; and 4) notable successful applications of that training. Similarly, Chapter III focuses on these same topics in the field of medicine. Finally,

---

[92] President's Task Force on 21st Century Policing, *Final Report of the President's Task Force on 21st Century Policing* (Washington, DC: Office of Community Oriented Policing Services, 2015), 3.

[93] Murray, *Training at the Speed of Life*.

[94] Ken Murray, "Spotlight on Training: The Misunderstood Concept of 'No Pain, No Gain,'" Police1, August 1, 2005, https://www.police1.com/archive/articles/spotlight-on-training-the-misunderstood-concept-of-no-pain-no-gain-1Dtz2QCcdfrIyQMr/.

Chapter IV presents conclusions, law enforcement training and policy recommendations, and future research suggestions.

II. THE AVIATION SECTOR'S TECHNOLOGY-BASED, SELECTIVE-FIDELITY TRAINING

The earliest pilots quickly realized the inherent dangers of flying and the benefit that flight simulators could provide to enhance skills and abilities. On December 17, 1903, the Wright brothers, Wilbur and Orville, successfully flew at Kitty Hawk, North Carolina, for under one minute.[95] Less than a decade later, on September 17, 1908, Thomas Selfridge died during a flight—with Orville Wright piloting—in Fort Myer, Virginia.[96] Shortly thereafter, in 1910, French airplane manufacturer Antoinette developed the first training simulator, depicted in Figure 4, built of "two wooden barrel halves, one placed on a pedestal and the other representing a swing cockpit."[97] A pilot sat atop the device, and men outside moved the device to create various "flight atmosphere scenarios."[98] Since then, the growth of aviation training simulation has been impressive. Today, modern flight simulators are highly sophisticated, often blurring the distinction between reality and simulation. Moreover, simulation has grown into its own specialized subsector within the aviation industry.

---

[95] "Wright Brothers," History, November 13, 2020, https://www.history.com/topics/inventions/wright-brothers.

[96] Mary Bellis, "History of Flight: The Wright Brothers—Invention of the First Powered, Piloted Airplane," ThoughtCo, July 3, 2019, https://www.thoughtco.com/history-of-flight-the-wright-brothers-1992681.

[97] Nathan Brewer, "Your Engineering Heritage: Antoinette and Early Flight Simulation," IEEE-USA InSight, November 13, 2019, https://insight.ieeeusa.org/articles/history-early-flight-simulation/.

[98] Brewer.

Figure 4. Antoinette Barrel[99]

A. TECHNOLOGY TYPES

The aviation industry comprises three subsectors: commercial, private, and military. Furthermore, each subsector has established different classification systems and distinct nomenclature for their respective technology-based training aids. However, each subsector generally organizes its training aids on a continuum of relative fidelity—from low to high—as illustrated in Figure 5. The more an aviation simulator matches or approximates its real-world counterpart, the higher its fidelity. As discussed earlier, fidelity comprises physical, functional, and behavioral components.

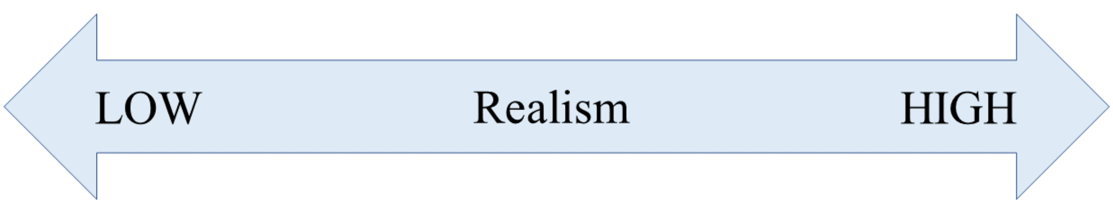

Figure 5. Fidelity Continuum

[99] Source: Brewer, "Antoinette and Early Flight Simulation."

In the United States, commercial aviation employs flight-simulator training devices (FSTDs), of which there are two primary categories—stationary and motion-based. A stationary FSTD is a designated flight training device whose complexity is measured on a scale from Level 1 to 7, where Level 7 is the most sophisticated.[100] A motion-based FSTD is called a flight simulator (FS), and its classification reflects an alphabetic designation of A, B, C, or D, the latter being the most sophisticated.[101]

The more sophisticated the components, the higher the level of the FSTD. For example, as with a real airplane, a Level 5 FSTD is equipped with physical primary and secondary flight controls for rudders, ailerons, elevators, flaps, speed brakes, engine controls, landing gear, nosewheel steering, trim, and brakes. Level 7 simulators must have "a visual system that provides an out-of-the-flight deck view" and "cross-flight deck viewing (for both pilots simultaneously) of a field-of-view of at least 180° horizontally and 40° vertically."[102] Visual awareness is vital for many reasons, including safety and flight performance. According to Covelli et al., pilots visually assess their environment for better "situational awareness," which results in improved performance.[103] Having physical controls and a more representative field of view closely matches actual airplanes and real-world conditions. These high-fidelity devices have elevated physical, functional, and behavioral fidelity.

B. EFFICACY OF TECHNOLOGY-BASED, SELECTIVE-FIDELITY METHODS

This section explores the efficacy of technology-based, selective-fidelity training devices and methods in aviation, focusing mainly on stress mitigation, the impact of device fidelity on effectiveness, and a comparison of simulated training to its counterpart in the real world—three areas relevant to law enforcement training. Stress is common in many

[100] "The Differences between Types of Flight Simulators Explained," *AeroCorner* (blog), accessed August 25, 2022, https://aerocorner.com/blog/types-of-flight-simulators/.

[101] "Differences between Types of Flight Simulators."

[102] 14 C.F.R. 60(4) (2022), Appendix B, https://www.ecfr.gov/current/title-14/chapter-I/subchapter-D/part-60#p-Appendix-B-to-Part-60()(4).

[103] Javier M. Covelli et al., "Field of View Effects on Pilot Performance in Flight," *International Journal of Aviation Psychology* 20, no. 2 (2010): 197–219, https://doi.org/10.1080/10508411003617888.

law enforcement encounters, so knowing the efficacy of specific technology-based, selective-fidelity training methods may benefit law enforcement training. A broad range of low- and high-fidelity training devices exist in the marketplace, so understanding the efficacy of these devices may assist the law enforcement training community in making sound selection decisions. Finally, technology-based, selective-fidelity training methods might be less effective than real-world training, so recognizing the limitations of these methods could guide law enforcement trainers in their curriculum development.

1. Stress and Performance

Stress is a physiological and psychological response to stimuli, which can manifest physically and mentally, leading at times to decreased performance.[104] Specifically, within aviation, stress can diminish cognitive skills; impede effective decision-making; and reduce psychomotor skills, attention, and procedural memory among pilots.[105] According to Koglbauer, "Declarative memory refers to the conscious recollection of facts and events using a mental model of the external world, whereas procedural memory is expressed through performance rather than recollection."[106] This framework is representative of Bloom's taxonomy, and aviators perform tasks associated with declarative and procedural memory. Consequently, the better pilots can tolerate stress, the better their overall performance. Pilots can develop stress tolerance through experience. However, real-world training and experiences are risky because stress-induced performance deficiencies can be deadly.

Researchers have evaluated the effectiveness of FSs in developing stress tolerance. McClernon et al. determined that introducing artificial stress and effective coping mechanisms in FS training improved actual flight performance.[107] McClernon et al. recruited 30 participants, none of whom had flown before, and divided them into a stress training group and a control group. Both groups received flight-simulator training before a

[104] McClernon et al., "Stress Training Improves Performance."

[105] McClernon et al.

[106] Koglbauer, "Simulator Training Improves Pilots' Procedural Memory," 358.

[107] McClernon et al., "Stress Training Improves Performance."

skills test in an actual aircraft. During its simulator training, the stress training group received a stress stimulus—a cold pressor of 9°C, which served as a noticeable distraction and impediment to learning—and practiced stress mitigation techniques. The stress mitigations techniques consisted of the following advice provided during the simulator training:

> During exposure to the cold pressor, or any stress, it is important to first maintain your normal breathing as best as possible. This will help calm and relax you. Next attempt to focus on the task at hand and ignore the distraction of the stressor. Finally, pay especially close attention to the performance parameters that you are asked to fly.[108]

Immediately after the flight-simulator training, both groups advanced to actual aircraft to assess skill acquisition and the ability to tolerate stress. Researchers measured flight performance in two ways: telemetry recordings and evaluations from certified flight instructors.[109] The air-telemetry data, which are objective measurements of flight inputs, demonstrate "how smoothly the aircraft is traveling through the air."[110] Researchers determined participants' stress levels by analyzing responses to a subjective stress assessment survey administered throughout the test flight.

In-flight performance test results revealed that participants from the stress-involved simulator training group performed better than their non-stressed counterparts. The stress cohort performed better on air-telemetry evaluations and received higher scores on their subjective assessments.

2. Effect of Fidelity Level on Simulator Efficacy

Aviation training simulators vary in terms of their realism. Again, realism is the product of physical, functional, or behavioral fidelity elements. Generally, simulators are divided into two broad categories: low fidelity and high fidelity. Upon initial consideration, one may assume that only high-fidelity simulators can be effective; however, research has

---

[108] McClernon et al., 210.

[109] McClernon et al.

[110] McClernon et al.

shown simulators on both ends of the spectrum can improve real-world performance and physical skills.

a. High-Fidelity Simulators

High-fidelity training devices can be efficacious in developing a range of learning objectives. Airplane loss of control can occur rapidly without warning and result in injury or death. Koglbauer researched whether pilots could better recover from loss-of-control events with a "series of memory items and coordinated actions."[111] Respectively, memory items are consistent with lower-order learning and coordinated actions with upper-order learning. Koglbauer's research determined that pilots could develop both skillsets with a high-fidelity flight training simulator.

To test her hypothesis, Koglbauer employed a high-fidelity simulator to assess performance. The simulator "was a fixed base trainer with genuine mechanical interior installations (e.g., two seats, couple controls, throttle quadrant, instrument panels, switches, and interior lining)" and a "blend [of] three channels into one single wide image covering more than 180° horizontal vision angle, thus providing realistic scenery simulation and peripheral vision stimulation."[112] This simulator had elevated physical, functional, and behavioral fidelity.

The research study involved 31 pilots, each with fewer than 450 hours of flight experience and no aerobatic experience.[113] In addition to practiced maneuvers, the trained group also performed better on unexpected maneuvers. In conclusion, these researchers confirmed their hypothesis that the high-fidelity simulator could improve flight performance.[114]

---

[111] Koglbauer, "Simulator Training Improves Pilots' Procedural Memory."

[112] Koglbauer, 362.

[113] Koglbauer.

[114] Koglbauer.

b. Low-Fidelity Simulators

Koglbauer's research confirmed a reasonable belief: that high-fidelity simulation can be effective. However, on the other end of fidelity, researchers have also found that lower-fidelity simulators can improve performance. In another attempt to improve pilot performance with the aid of simulation, researchers used a relatively basic approach with a computer-based simulation training system.[115] Specifically, in this study, researchers used a personal computer to develop visual flight rules (VFR) effectively.[116] Personal computers have nearly no physical or functional fidelity and, based on the quality of the software program, varying degrees of behavioral fidelity.

As described by Reweti, Gilbey, and Jeffrey, "VFR procedures [are] a set of regulations under which a pilot operates an aircraft in weather conditions generally clear enough to allow the pilot to see where the aircraft is going."[117] Generally, VFR flight is more straightforward than instrument flight rules. Yet, VFR is still challenging, and Reweti and his colleagues wanted to understand the efficacy of a computer-based training system versus more-sophisticated methods for improving VFR performance.

Reweti, Gilbey, and Jeffrey determined that the low-fidelity, computer-based training simulator was as effective as a high-fidelity alternative.[118] First, these researchers developed a hypothesis: more-sophisticated simulators better develop skills and abilities than their low-fidelity training counterparts. Next, the study's participants received training in either high-fidelity or low-fidelity simulators or received no training at all.[119] This last group served as a control group.[120] A desktop computer and Microsoft Flight Simulator

---

[115] Savern Reweti, Andrew Gilbey, and Lynn Jeffrey, "Efficacy of Low-Cost PC-Based Aviation Training Devices," *Journal of Information Technology Education: Research* 16 (2017): 127–42, https://doi.org/10.28945/3682.

[116] Reweti, Gilbey, and Jeffrey.

[117] Reweti, Gilbey, and Jeffrey, 131.

[118] Reweti, Gilbey, and Jeffrey.

[119] Reweti, Gilbey, and Jeffrey.

[120] Reweti, Gilbey, and Jeffrey.

served as the low-fidelity simulator.[121] As noted earlier in this research study, Microsoft Flight Simulator has elevated behavioral fidelity. A FRASCA single-engine PA-28 flight simulator served as the high-fidelity simulator—possessing high physical fidelity (realistic controls and interface), high functional fidelity (realistic response from inputs), and behavioral fidelity (cognitive alignment between actual and simulated flight).[122] The test involved completing the standard overhead rejoin procedures, which consists of the following systematic steps:

1. Radio call
2. Track to keep aerodrome on your left (no less than 1500 feet)
3. Determine runway in use: Make all turns in the direction of the circuit
4. Descend on the non-traffic side
5. Cross upwind threshold at circuit altitude
6. Join downwind leg[123]

The test measured both the precision and timeliness of the pilot's performance.

In conclusion, the researchers discovered that the group trained on the low-fidelity, computer-based simulator performed just as well as the group trained on the high-fidelity FRASCA PA-28.[124] Furthermore, as might be expected, both groups performed better than the untrained control groups. Consequently, this study's findings indicate that low-fidelity and high-fidelity simulators may develop certain skills and abilities equally.

3. Advanced Skill Level Development and Simulators

The U.S. Navy's elite aviators must perform well—lives and millions of dollars in assets depend on it. The U.S. Navy describes the mission of their pilots as follows: "Among the most daring and most important. Complete air maneuvers while flying at Mach speed. Catapult off carriers at 170 mph and land on moving runways only 300 feet long. Gather intel, drop ordinance, and conduct defensive missions."[125]

[121] Reweti, Gilbey, and Jeffrey.

[122] "Piper Archer Flight Simulation Training Device," FRASCA Flight Simulation, accessed August 25, 2022, https://www.frasca.com/products/piper-archer/.

[123] Reweti, Gilbey, and Jeffrey, "Low-Cost PC-Based Aviation Training Devices."

[124] Reweti, Gilbey, and Jeffrey.

[125] "Fighter Pilot," U.S. Navy, accessed August 25, 2022, https://www.navy.com/flynavy.

Flight simulators are a part of the training and development of U.S. Navy pilots. Aspiring naval aviators begin training at the Naval Aviation Schools Command in Pensacola, Florida.[126] Afterward, successful aviators advance to intermediate training pipelines, which include simulators and airplanes. Finally, pilots who move on to the final phase of training, called mission-specific instruction, are considered to have advanced-level skills.[127]

Judy and Gollery wanted to better understand the effectiveness of various fidelity training methods for developing complex skills, specifically those required by intermediate and advanced naval pilots. Specifically, Judy and Gollery questioned how high-fidelity flight simulators compared to actual flight time in developing aviation skills.[128] Their study included an impressive sample size of "358 intermediate flight students and 334 advanced flight students" in the U.S. Navy.[129]

The study compared the naval standard score (NSS) of intermediate and advanced naval flight students to their respective training time in flight simulators and actual flights.[130] According to Binkley, Moreno, and Zenga, the NSS is "calculated based on student performance and is normalized to account for potential abnormalities in the distribution of [a naval flight student's] phase aggregate score."[131] The high-fidelity training simulator was the T-45C OFT, and the actual aircraft was the T-45C, an advanced two-seat jet trainer.[132] In conclusion, Judy and Gollery determined that actual training flight time was more predictive of a pilot's NSS than high-fidelity simulator training time.

---

[126] U.S. Navy.

[127] U.S. Navy.

[128] Aaron Judy and Thomas Gollery, "U.S. Navy Pilot Competence: An Exploratory Study of Flight Simulation Training versus Actual Aircraft Training," *Journal of Applied Social Science Research and Practice* 1 (2019): 4–33.

[129] Judy and Gollery.

[130] Judy and Gollery.

[131] Jeremiah Binkley, Michael Moreno, and Ronald Zenga, *Minimum NSS to Select Rotary Wing*, EMBA Project Report (Monterey, CA: Naval Postgraduate School, 2008).

[132] "T-45A/C Goshawk," Naval Technology, June 8, 2000, https://www.naval-technology.com/projects/t45-goshawk/.

In addition, both intermediate and advanced pilots preferred actual flight training to high-fidelity training simulator time.[133]

In conclusion, research by McClernon et al. found that simulator training can mitigate stress and improve performance. Furthermore, clear and concise instructions on deliberate breathing, controlled focus, and directed attention may contribute to that improved performance. Koglbauer's research established that high-fidelity simulation can be effective, and research by Reweti and his colleagues found the same for low-fidelity training devices. Finally, Judy and Gollery's study determined that actual flight time rivaled high-fidelity training devices in developing advanced pilots' higher-order learning.

C. STANDARDS, POLICIES, AND PROCEDURES

Today, the Federal Aviation Administration (FAA) oversees all aspects of the aviation industry in the United States, controls all aviation within U.S. airspace, and regulates aviation simulator training devices. The FAA and the airline industry are intently focused on safety, and the two have worked together to develop stringent regulations for initial training and continuing education involving simulators. These strict regulations provide consistency across the aviation industry, which includes dozens of airlines and manufacturers, hundreds of airplane types, and thousands of flight routes spanning the continent. As a note, this thesis reviews the FAA's rules and regulations, which are more readily available than those for military aviation, to gain insights into aviation standards, policies, and procedures surrounding technology-based, selective-fidelity training methods.

1. Commercial Aviation, Standards, Policies, and Procedures

According to the FAA, the "use of . . . training devices has proven to be an effective, safe, and affordable means of obtaining pilot experience."[134] Consequently, the FAA

[133] Judy and Gollery, "U.S. Navy Pilot Competence."

[134] Regulatory Relief: Aviation Training Devices; Pilot Certification, Training, and Pilot Schools; and Other Provisions,82 Fed. Reg. 30232 (June 27, 2018), https://www.federalregister.gov/documents/2018/06/27/2018-12800/regulatory-relief-aviation-training-devices-pilot-certification-training-and-pilot-schools-and-other.

allows pilots of every type to learn on simulators. Flight schools and airlines use simulators for both initial and ongoing pilot training. Moreover, there are multiple pilot certifications and ratings, depending on the airplane and conditions of flight. Finally, pilots combine simulation and actual flight to gain knowledge, skills, and experience.

The FAA's National Simulator Program branch oversees all aspects of flight simulators, including their manufacturing specifications.[135] Simulators are rarely generic representations of airplanes; instead, they are close duplicates of specific planes based on manufacturers and models. This specificity allows student pilots to learn precisely about the aircraft they intend to fly, so to ensure that simulators match the airplane it wants to represent, the National Simulator Program branch mandates simulator manufacturers secure a letter of authorization for each simulator.[136] This letter provides a five-year window in which pilots may use a specific simulator for training on a particular airplane type. Furthermore, the National Simulator Program dictates how much simulator training is allowed for initial certification or recertification.

One of the most interesting developments in the standards, procedures, and policies surrounding flight simulators has been a change to the allowable simulator training hours for initial certification and recertification. In 2016, the FAA increased the allowable simulator training for certification from 3.5 to 20 hours because of continuous improvements in simulator quality, cost-effectiveness, and performance consistency.[137]

2. Successful Application

Flight-simulator training helps pilots reduce stress, improve focus and attention, and address novel or unpredictable crisis scenarios. Captain Chelsey "Sully" Sullenberger's emergency landing of American Airlines Flight 1549 in the Hudson River near New York City on January 15, 2009, is a real-world example of these benefits of simulator training.

[135] Federal Aviation Administration, "National Simulator Program."

[136] Federal Aviation Administration, "FAA Approved Aviation Training Devices."

[137] "FAA Issues New Flight Simulator Regulations," Federal Aviation Administration, April 14, 2016, https://www.faa.gov/news/updates/?newsId=85426.

Flight 1549 began normally, and the crew did not expect it would perform an unprecedented high-risk aviation maneuver that day. During an interview, Captain Sullenberger described the initial moments of the event, saying, "January 15, 2009, started just like 10,000 other days, and Flight 1549, like all those other flights for so long, was completely routine and unremarkable for the first 100 seconds."[138] However, the ordinary suddenly turned extraordinary because of a flock of Canadian geese. Sullenberger recounted how these birds struck the airplane soon after take-off, impacted the fuselage, entered both turbine engines, and caused a dual-engine failure. Sullenberger described an immediate loss of power, and the airplane began to fall like an elevator, "descending at two floors per second."[139] Yet, Captain Sullenberger and the co-pilot overcame these monumental obstacles and safely landed the Airbus A320 in the Hudson River, and all 155 passengers and crew members survived. This landing became popularly known as the "Miracle on the Hudson."

Flight-simulator training contributed to the Miracle on the Hudson in linear and non-linear ways. Sometimes flight simulation training improves future performance by providing pilots with an opportunity to practice specific situations precisely as they unfold in real-world conditions. According to then–American Airlines Chairman and CEO Doug Parker, the acts of Captain Sullenberger were "an example of great skill and professionalism produced by years of training and experience."[140] Part of that training included simulator training specific to his rating type at least once every three quarters.[141] During these training sessions, pilots practice emergency procedures involving "engine failures, wind shear, total hydraulic failure and two-engine loss at high altitude."[142] These training opportunities mirror some of the issues that Sullenberger faced.

---

[138] Inc., "Captain Sully's Minute-by-Minute Description."

[139] Inc.

[140] "American Airlines Marks the 10th Anniversary of the 'Miracle on the Hudson,'" American Airlines, January 15, 2019, https://news.aa.com/news/news-details/2019/American-Airlines-Marks-the-10th-Anniversary-of-the-Miracle-on-the-Hudson/default.aspx.

[141] Andrew Prince, "Experience, Training Make for Smooth River Landing," National Public Radio, January 16, 2009, https://www.npr.org/templates/story/story.php?storyId=99476650.

[142] Prince.

However, other times, simulator training sows the seeds for success by cultivating transferable skills like the ability to improvise, extrapolate, and adapt in the moment. Captain Sullenberger recounted how his flight-simulator training did not provide water-landing scenarios. Instead, he had only participated in theoretical classroom discussions on the topic.[143] However, Sullenberger described landing American Airlines Flight 1549 in the Hudson as a series of automatic responses he had developed because of his repeated sessions practicing emergencies in a simulator.[144] These automatic responses included stress management, focus and attention, problem-solving, and performance in novel situations. Although the next subsections address each quality individually, these responses overlap and interconnect in practice. These are the indirect ways flight-simulator training influenced Captain Sullenberger's performance.

a. Stress Management

In her study, Koglbauer learned that pilots could manage and mitigate stress by focusing on the most pressing task. Captain Sullenberger recalled the extreme stress he initially experienced in his account: "I could feel my pulse shoot up, my blood pressure spike, my perceptual field narrow in tunnel vision because of my stress."[145] In addition, he remembered thinking in quick succession, "This can't be happening," and "This doesn't happen to me."[146] These thoughts, according to Sullenberger, were his mind's attempt to make sense of the improbable event unfolding around him. However, within moments, he calmed himself, accepted that his airplane had lost both engines, and committed to finding a solution.[147] This quick self-diagnosis and situational awareness served as the first steps to managing his stress and redirecting his focus toward fixing the problem.

[143] Inc., "Captain Sully's Minute-by-Minute Description."

[144] Allen Interactions.

[145] Inc., 2:01.

[146] Inc., 2:12.

[147] Inc.

b. Focus and Attention

The Koglbauer study also confirmed that effective simulator training could teach pilots to narrow their focus and attention, thereby improving task performance. Focus and attention can be challenging to measure. Still, in the Koglbauer study, the most effective participants executed the most appropriate response to the loss-of-control event through "power-push-roll-recover" maneuvers.[148] Furthermore, the best performers executed the maneuver the fastest, as timeliness is a measure of focus and attention. Consequently, the Koglbauer study demonstrated how flight-simulator training could engrain in trainees the correct response to a loss-of-control event and improve timeliness.

Similarly, the outcome of the Flight 1549 emergency might not have ended as well had it not been for Captain Sullenberger's focus and attention. Sullenberger described this acute focus as the discipline "to ignore everything I didn't have time to do as being only distractions and potential detriment to our performance."[149] Moreover, although Sullenberger did not directly attribute his focus and attention to his significant flight-simulator training, connecting his training with his ability to focus and intentionally direct his attention is reasonable.

Captain Sullenberger's focus and attention led to practical default actions and unique problem-solving. After quickly recognizing Flight 1549's imminent peril, he focused solely on what he described as the "highest priority items"—three pertinent tasks, the product of his emergency checklist simulator training.[150] First, Sullenberger turned on the engine ignition system, "so if the engines could recover, they would."[151] Next, he started the plane's auxiliary power unit, allowing him to operate the plane's controls. Third, he considered his landing zone options: LaGuardia Airport (New York City), Teterboro Airport (Teterboro, NJ), and the Hudson River, which separates New York and New Jersey. Figure 6 illustrates the relative position of Flight 1549, shown in red, and these landing

---

[148] Koglbauer, "Simulator Training Improves Pilots' Procedural Memory," 358.

[149] Inc., "Captain Sully's Minute-by-Minute Description," 3:21.

[150] Inc., 3:15.

[151] Inc., 4:02.

options during the flight. While Sullenberger considered landing at Teterboro Airport (the dark blue route) or heading back toward LaGuardia Airport (the pink route), he chose to land in the river.

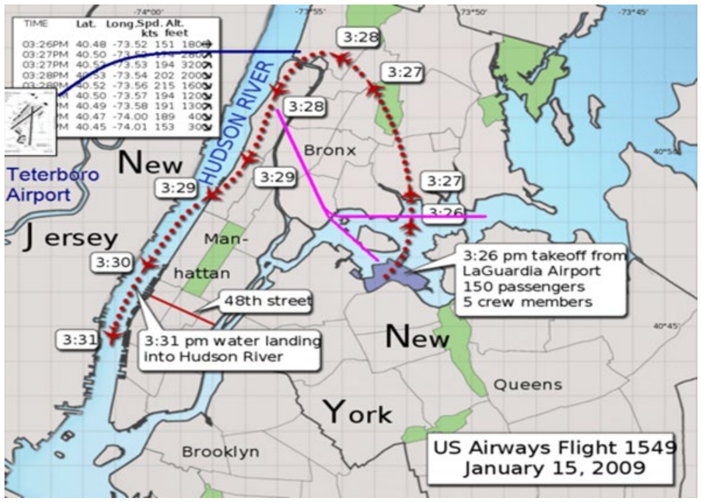

Figure 6. Sullenberger’s Flight Path on January 15, 2009[152]

Addressing the first two issues, the engine ignition system and auxiliary power, were relatively simple tasks predicated on a straightforward stimulus–response methodology. Captain Sullenberger’s flight-simulator training, like the training in the Koglbauer study, inculcated specific immediate default actions to known problems. According to Bloom’s taxonomy, such default reactions are comparative to lower-order thinking tasks. However, the third problem—where to land the airliner—required more complex analysis and creative thought, or higher-order thinking, according to Bloom’s taxonomy.

c. Novel Situations

Captain Sullenberger’s flight-simulator training did not involve low-altitude, dual-engine failure over a densely populated urban environment. However, based on his

[152] Source: Wikipedia, s.v. “US Airways Flight 1549,” last modified September 8, 2020, https://simple.wikipedia.org/wiki/US_Airways_Flight_1549.

experience and training, Sullenberger developed and executed an effective emergency plan. His flight-simulator training not only engrained in him an immediate default checklist—if the engine fails, toggle engine restart; if the power fails, activate auxiliary power—it also freed his mind to conduct higher-order thinking. Sullenberger completed the mental gymnastics necessary to determine the best place to land in this case.

Amazingly, Captain Sullenberger completed this final priority, a three-airport feasibility analysis, in seconds.[153] Given the distances involved and the plane's condition (bilaterally symmetrical loss of thrust), Sullenberger calculated that the waterway was the only feasible option. In 2009, before the U.S. House Subcommittee on Aviation, Sullenberger testified, "The only place that was large enough, wide enough, smooth enough to land a jet airliner was the Hudson."[154]

Captain Sullenberger's transfer of conventional training to an unconventional problem is reminiscent of the students in Koglbauer's study. The latter performed better in novel tasks than their counterparts in the control group. As a reminder, students in the study who received artificial stressors during training and coping mechanisms performed better on known problems and unexpected issues. Sullenberger's real-life experiences support this research study's findings, that effective flight-simulator training better prepares students for foreseeable and unforeseen issues. Captain Sullenberger dismissed the stress, focused on the situation, and freed his mind to work on the novel problem. Finally, as a testament to his belief in simulator training, Captain Sullenberger recommended to the House Subcommittee on Aviation, "We should all want pilots to experience these challenging situations for the first time in a simulator, and not with passengers and crew on board."[155]

---

[153] Inc., "Captain Sully's Minute-by-Minute Description."

[154] *US Airways Flight 1549 Accident: Hearing before the Subcommittee on Aviation of the Committee on Transportation and Infrastructure House of Representatives*, 111th Cong., 1st sess. (2009), 14, https://www.govinfo.gov/content/pkg/CHRG-111hhrg47866/pdf/CHRG-111hhrg47866.pdf.

[155] Leslie Josephs, "'Miracle on the Hudson' Pilot Urges Simulator Training for the Boeing 737 Max," CNBC, June 19, 2019, https://www.cnbc.com/2019/06/19/miracle-on-the-hudson-pilot-urges-boeing-737-max-simulator-training.html.

D. SUMMARY

Overall, the aviation industry has leveraged technology-based, selective-fidelity training devices and methods to improve performance. The nascent industry in the 19th century developed rudimentary devices to improve performance. Since then, aviation has continually incorporated technological advances, and today, sophisticated simulators provide incredibly high-fidelity training. Furthermore, the aviation industry has unified the policies, procedures, and standards surrounding technology-based, selective-fidelity training methods. Aviation research has shown that both low- and high-fidelity training methods can be effective; flight simulators can help mitigate stress, refine focus, and control attention; and the most-advanced pilots may greatly benefit from actual flight training. Finally, Captain Sullenberger and Flight 1549 illustrate how technology-based, selective-fidelity training methods can contribute to real-world successes.

THIS PAGE INTENTIONALLY LEFT BLANK

III. THE MEDICAL SECTOR'S TECHNOLOGY-BASED, SELECTIVE-FIDELITY TRAINING

The aviation industry's utilization of technology-based, selective-fidelity devices and methods are well known. However, other fields, like the medical sector, recognize these methods' benefits. In a nod to the aviation industry, Dr. David Gaba of Stanford University's medical school commented, "You wouldn't get on an airplane unless the pilot had been training in a flight-simulator and certified to use the new instruments on a jet. Why would you place yourself in the hands of a doctor who hadn't proven his competency and been certified on a simulator?"[156] Today, the medical sector—from medical schools to specialized surgical training programs—is saturated with selective-fidelity training methods.

Understanding the use of selective-fidelity training methods in the medical sector is important because of the commonalities between the medical industry and law enforcement. Medical practitioners, like police officers, face situations involving risk, information deficiency, and critical decision-making. Consequently, this thesis might gain valuable insights from a better understanding of the medical sector's use of selective-fidelity training methods and its real-world successes. Next, this thesis explores the various types of selective-fidelity training methods used in the medical sector; the efficacy of those methods; and the standards, policies, and procedures surrounding their use. Finally, it reviews the successful real-world use of selective-fidelity training methods in the medical sector.

A. TECHNOLOGY TYPES

People have known for centuries that selective-fidelity training methods can enhance understanding and learning in medicine. For example, in the distant past, our ancestors used a very basic medical tool—human figurines depicting particular ailments—

[156] "Media Monitor," *Stanford Report*, May 11, 2005, https://news.stanford.edu/news/2005/may11/med-mmonitor-051105.html.

to help understand disease and diagnosis conditions.[157] In the third century, Herophilus of Chalcedon and Erasistratus of Ceos realized the value of meticulously understanding human anatomy and systematized cadaveric dissection.[158] More recently, in the 18th century, childbirth mortality rates (for both mother and child) decreased with Angélique Marguerite Le Boursier du Coudray's "cloth birthing simulator," depicted in Figure 7.[159] In the 1960s, the Resusci-Anne mannequin helped healthcare providers and the general public to learn mouth-to-mouth ventilation and cardiac compressions.[160] Recently, technological advances—namely, high-speed processors and networking—have supported an array of selective-fidelity training methods across the medical community.

Figure 7. 18th Century Obstetric Simulators[161]

In the United States, the medical sector is decentralized—unlike the aviation sector, which is overseen primarily by the FAA—and consists of many governing and regulatory

[157] Paul Bradley, "The History of Simulation in Medical Education and Possible Future Directions," *Medical Education* 40, no. 3 (March 2006): 254–62, https://doi.org/10.1111/j.1365-2929.2006.02394.x.

[158] Sanjib Kumar Ghosh, "Human Cadaveric Dissection: A Historical Account from Ancient Greece to the Modern Era," *Anatomy & Cell Biology* 48, no. 3 (September 2015): 153–69, https://doi.org/10.5115/acb.2015.48.3.153.

[159] "History of Simulation," Rahmi M. Koç Academy of Interventional Medicine, Education, and Simulation, accessed August 25, 2022, https://www.aimes.org/en/page/about-us/history-of-simulation.

[160] Felipe Jones, Carlos Eduardo Passos-Neto, and Odonne Freitas Melro Braghiroli, "Simulation in Medical Education: Brief History and Methodology," *Principles and Practice of Clinical Research Journal* 1, no. 2 (2015): 46–54, https://doi.org/10.21801/ppcrj.2015.12.8.

[161] Source: Rahmi M. Koç Academy of Interventional Medicine, Education, and Simulation, "History of Simulation."

agencies. Moreover, a wide variety of primary and advanced medical professionals practice medicine across multiple settings (e.g., hospitals, clinics, and small private practices). Consequently, no one agency is responsible for categorizing technology-based, selective-fidelity training methods. Yet, some have worked to define these devices better; one individual is Guillaume Alinier.[162] Alinier has created a sense-making framework for technology-based, selective-fidelity training methods in medicine. After analyzing the available selective-fidelity training methods, Alinier divided them into six categories based on their fidelity, from Level 0 (least realistic) to Level 5 (most realistic).[163] In addition, although Alinier refers to each level as a form of "simulation," only Levels 1–5 involve interactions with technology. Table 1 provides an overview of Alinier's typology of simulation.

[162] Alinier, "Educationally Focused Medical Simulation Tools."

[163] Alinier.

Table 1. Alinier's Typology of Simulation Methodologies[164]

Level	Simulation Technique	Modes of Delivery	Facility Required	Typical Use	Type of Skills Addressed
0	Written material; latent images	Usually student-led	Classroom	Patient management problems; diagnosis mainly for assessments	Passive cognitive
1	3-D models; basic mannequins; low-fidelity simulations models; part-task simulators	Student- or trainer-led	Clinical skills room or classroom	Demonstration and practice of skills	Psychomotor
2	Screen-based simulator/ computer-based simulation; simulation software, videos; VR simulators	Student- or trainer-led	Multimedia/computer laboratory or classroom	Cognitive skills; clinical management; sometimes interpersonal skills (software allowing for a team to interact over networked computers)	Interactive cognitive
3	Standardized patients; real or simulated patients (trained actors); role players	Student- or trainer-led	Depends on scenario requirements	Same as Level 2, plus patient physical assessment, diagnosis, or management problems; interpersonal skills	Psychomotor, cognitive, and interpersonal
4	Intermediate-fidelity patient simulators; computer-controlled, programmable full-body-size patient simulators	Preferably trainer-led	Clinical skills room or simulation center with realistic setting (simulated theatre, ICU, A&E or ward)	Same as Level 3, plus procedural skills; full-scale simulation training; sometimes used for demonstrations	Psychomotor, cognitive, and interpersonal
5	Interactive patient simulators or computer-controlled model driven by patient simulators, high-fidelity simulation platforms	Preferably student-led	Simulation centre with realistic setting (simulated theatre, ICU, A&E or ward) usually set up with audio and video recording equipment	Same as Level 4	Psychomotor, cognitive, and interpersonal

[164] Adapted from Alinier, "Educationally Focused Medical Simulation Tools," e245.

Alinier's work to divide selective-fidelity training methods into discrete categories is informative in that it provides a common understanding, language, and guidance for their usage within the healthcare industry. Yet, Alinier's application of Miller's pyramid to his categorization system is also of interest, as depicted in Figure 8. Alinier proposed that the best result could be achieved by matching the proper simulation method to the appropriate learning objective. When Alinier considered learning objectives (e.g., cognitive, psychomotor, interpersonal), he also measured the complexity of the learning objective (i.e., upper-order versus lower-order).[165] Moreover, according to Alinier, higher-fidelity simulation better develops higher levels of learning.[166]

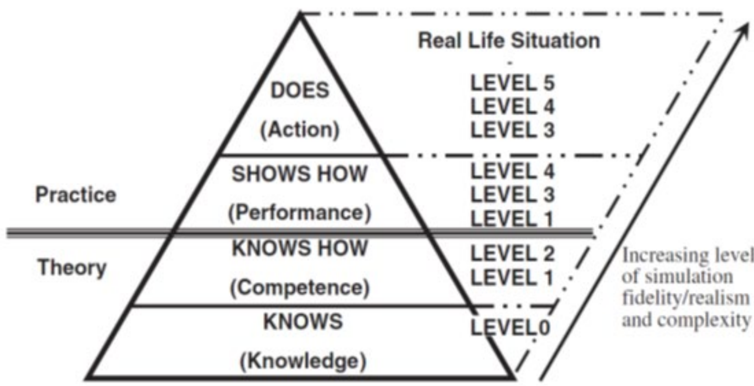

Figure 8. Framework for Acquisition of Experience and Skills in Simulation Training Adapted to Miller's Pyramid[167]

Miller's pyramid is reminiscent of and analogous to Bloom's taxonomy, so it is reasonable to draw parallels. Alinier offers that training methods of the highest fidelity facilitate elevated learning objectives on Miller's pyramid. Consequently, given the commonality between Miller's pyramid and Bloom's taxonomy, Alinier's framework

[165] Alinier.

[166] Alinier.

[167] Source: Alinier, "Educationally Focused Medical Simulation Tools," e246.

suggests that higher-order training methods develop greater higher-order learning in Bloom’s taxonomy.

B. EFFICACY OF TECHNOLOGY-BASED, SELECTIVE-FIDELITY METHODS

This thesis aspires to understand how selective-fidelity training methods in aviation and medicine might improve law enforcement training and performance, in part through an exploration of the efficacy of selective-fidelity training methods in medicine. This section focuses on the efficacy of some low- and high-fidelity training methods and how fidelity training methods develop certain learning domains (i.e., lower and higher order). In addition, this section explores how selective-fidelity training methods compare to traditional teaching modalities and how the former might better engage students in the educational process and develop confidence.

1. Performance Improvement

Like aviation researchers, medical researchers have found that technology-based, selective-fidelity training methods can improve performance. For example, Kleinert et al. found that an immersive patient simulator called the Artificial Interface for Clinical Education (ALICE) could positively influence clinical knowledge and reasoning.[168] ALICE was a virtual outpatient clinic created to develop declarative and procedural knowledge.[169]

These researchers used a framework of declarative and procedural knowledge for their study. In concert, these elements provide the underpinnings “for mastering clinical workflows.”[170] The researchers defined declarative knowledge as what to do and procedural knowledge as how to do it.[171] As a link to the material presented earlier,

[168] Kleinert et al., “Web-Based Immersive Virtual Patient Simulators.”

[169] Kleinert et al.

[170] Kleinert et al., 2.

[171] Kleinert et al.

declarative knowledge is consistent with lower-order thinking while procedural knowledge is consistent with high-order thinking.

Kleinert et al. concluded that after completing ALICE simulator training, participants made better diagnoses and suggested better therapies. In comparing pre- and post-simulator training scores, the researchers found that correct oncological diagnoses had improved, from 62 percent to 95 percent, and appropriate therapeutic concepts had been enhanced, from 32 percent to 76 percent.[172] Overall, these researchers deemed ALICE effective at enhancing diagnostic and therapeutic skills. However, ALICE only marginally improved procedural knowledge, meaning that it better developed lower-order thinking than higher-order thinking.

Kleinert et al. applied two educational frameworks in their analysis: Bloom's taxonomy and Miller's pyramid. The researchers divided Bloom's taxonomy into two broad categories: foundational thinking and higher-order thinking. Foundational (or lower-order thinking) consisted of the remember, understand, and apply phases while higher-order thinking consisted of analyze, evaluate, and design (see Figure 9).[173] According to Kleinert et al., ALICE strongly developed Bloom's foundational thinking subcategories but only marginally improved its higher-order thinking.[174]

[172] Kleinert et al.

[173] Kleinert et al.

[174] Kleinert et al.

Figure 9. Bloom's Taxonomy of the Cognitive Domain[175]

Kleinert et al. also applied a second educational framework: Miller's pyramid. The creator, George Miller, specifically developed this hierarchical assessment tool to evaluate clinical competency. The framework consists of four tiers of competency, progressing from *knows*, to *knows how*, to *shows how*, to *does*.[176] The lower levels assess cognitive competency while the upper levels assess behavioral competency.[177] The latter consists of procedural knowledge and higher-order thinking (see Figure 10).

[175] Source: Kleinert et al., "Web-Based Immersive Virtual Patient Simulators," 4.

[176] "Miller's Pyramid of Assessment," Benedictine University, n.d., 1.

[177] Annamaria Witheridge, Gordon Ferns, and Wesley Scott-Smith, "Revisiting Miller's Pyramid in Medical Education: The Gap between Traditional Assessment and Diagnostic Reasoning," *International Journal of Medical Education* 10 (2019): 191–92, https://doi.org/10.5116/ijme.5d9b.0c37.

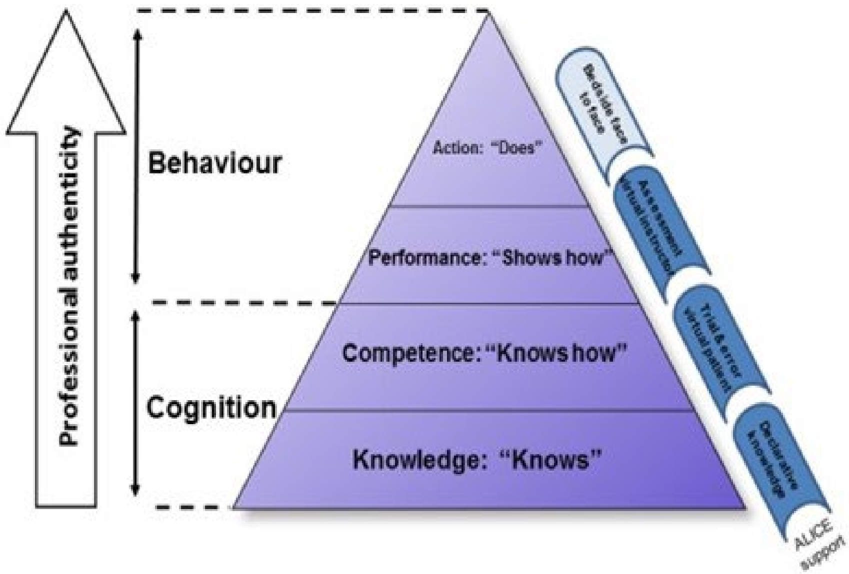

Figure 10. Simulator Design Based on Miller's Pyramid, Developed to Support Clinical Education[178]

As applied to Miller's pyramid, ALICE primarily improved cognitive competency or improvements on the lower levels of the framework (i.e., knowledge/knows and competence/knows how). However, these researchers were not confident that ALICE demonstrated the ability to develop performance in the upper levels of Miller's pyramid (i.e., performance/shows how and action/does).[179]

Consequently, as evaluated against Bloom's taxonomy and Miller's pyramid, the immersive virtual training simulator, ALICE, was not well suited to develop sophisticated clinical reasoning or higher-order thinking.[180] Specifically, the researchers did not believe that ALICE could improve the "affective and psychomotor domains, weighting clinical findings and evaluating different hypotheses, [and] professional attitude."[181] These skills are consistent with higher learning. The findings from this study are more persuasive when viewed through the lens of the two different learning frameworks.

[178] Source: Kleinert et al., "Web-Based Immersive Virtual Patient Simulators," 3.

[179] Kleinert et al.

[180] Kleinert et al.

[181] Kleinert et al., 9.

In addition, these researchers concluded that higher-order learning requires human interactions with teachers and simulated patients (role players). For example, the Objective Structured Clinical Examination (OSCE) is a traditional clinical learning environment in which human actors serve as mock patients during a practice medical evaluation. Kleinert et al. were dubious about "whether virtual simulated patients [could] replace [human] simulated patients in an OSCE environment."[182] In addition, they believed in "the experience of the teacher" as a more effective educational approach for achieving sophisticated clinical educational objectives.[183] Ultimately, the researchers determined that immersive simulation could not replace humans. Instead, the teacher and small student group combination best optimized advanced learning in the clinical setting.[184] Kleinert et al. maintained that the OSCE environment developed higher-order learning better than ALICE did.

ALICE's shortcomings in developing higher-order thinking might be related to its overall fidelity profile. Although ALICE created a VR environment, which is often presumed to be innately high-fidelity, the device might have had a relatively lower-fidelity profile overall. Specifically, although ALICE possessed representative behavioral fidelity, it had lower functional and physical fidelity components. Thus, ALICE provided cognitive realism—medical reasoning in ALICE's VR environment matched real-world medical decision-making—but within the virtual environment, interactions with artifacts did not match reality—holding a virtual item did not feel exactly like holding the real thing. In addition, ALICE provided lower "visual and auditory" realism—in other words, the virtual experience did not look and sound precisely like the real world.[185]

However, it is important not to overlook ALICE's benefits. ALICE was extremely effective at developing declarative knowledge (i.e., lower-order learning), which is necessary for effective medical workflows in the clinical setting. Notably, ALICE provided

---

[182] Kleinert et al., 9.

[183] Kleinert et al., 9.

[184] Kleinert et al.

[185] Allen Interactions.

repetitive opportunities for "standardized clinical settings," inculcating foundational knowledge for diagnoses and therapeutic recommendations for real patients in the future.[186]

The study also revealed another valuable insight into selective-fidelity training methods. In a post-training survey, many students indicated that they enjoyed the immersive virtual training environment, describing it as engaging, motivational, and fun.[187] Kleinert et al. found these opinions consistent with research by Gutierrez et al., which found that the level of immersion influences educational effectiveness and student engagement.[188] Moreover, a majority of students reported wanting more e-learning curricula, believing 3-D opportunities could enhance learning, and feeling that virtual human patient simulators encourage learning.[189]

In conclusion, the researchers did not prematurely conclude that ALICE was a panacea for all clinical education. While they had hoped ALICE would equally develop procedural and declarative knowledge, or lower- and higher-order thinking, they found that ALICE was best suited for developing foundational knowledge, providing individualized training programs (e.g., self-paced and specified curriculum), and measuring a student's knowledge to assess readiness for simulated human clinicals.[190]

2. High-Fidelity versus Low-Fidelity versus Traditional Methods

Other medical researchers have arrived at findings like those of Kleinert et al. For example, Beal et al. compared the relative efficacy of high-fidelity simulators, low-fidelity simulators, and traditional teaching methods in developing knowledge and performance in critical care medicine.[191] After conducting a 22-study meta-analysis, Beal et al. found that

---

[186] Kleinert et al.

[187] Kleinert et al.

[188] Kleinert et al.

[189] Kleinert et al.

[190] Kleinert et al.

[191] Matthew David Beal et al., "The Effectiveness of Medical Simulation in Teaching Medical Students Critical Care Medicine: A Systematic Review and Meta-Analysis," *Simulation in Healthcare* 12, no. 2 (April 2017): 104–16, https://doi.org/10.1097/SIH.0000000000000189.

no method offered advantages in building knowledge, but the authors concluded that the more realistic the simulator, the better the student's performance.[192] In their study, Beal et al. defined knowledge and performance. Within the context of this thesis, knowledge correlates with lower-order thinking whereas performance correlates with higher-order thinking. Thus, Beal et al. found that all three education modalities could equally develop lower-order learning and that high-fidelity training methods could better develop higher-order learning.

Understanding the efficacy of certain technology-based selective-training methods in critical care medicine is relevant for this thesis because of the commonalities between the target fields. Both involve complexity, information deficiency, and mortal risks. According to the American College of Physicians, "Critical care medicine encompasses the diagnosis and treatment of a wide variety of clinical problems presenting the extreme of human disease. Most physicians trained in critical care work in hospital-based settings, usually in intensive care units."[193] Effective critical care medicine involves both knowledge (lower-order learning) and performance (higher-order learning). For example, critical care practitioners must know what procedures are most appropriate and how to perform such procedures. A short list of critical care procedures includes airway management, central venous catheterization, and tracheostomy.[194] The death rate in intensive care units, which ranges from 20–35 percent, illustrates the direness of critical care medicine.[195]

The Beal et al. study examined the effectiveness of particular selective-fidelity training methods at enhancing two learning categories: knowledge (lower-order learning)

[192] Beal et al.

[193] "Critical Care Medicine," American College of Physicians, accessed June 16, 2021, https://www.acponline.org/about-acp/about-internal-medicine/subspecialties-of-internal-medicine/critical-care-medicine.

[194] "Critical Care," Mayo Clinic, accessed August 25, 2022, https://www.mayoclinic.org/departments-centers/critical-care/sections/tests-procedures/orc-20399607.

[195] Sebastiano Mercadante, Cesare Gregoretti, and Andrea Cortegiani, "Palliative Care in Intensive Care Units: Why, Where, What, Who, When, How," *BMC Anesthesiology* 18, no. 1 (December 2018): 106, https://doi.org/10.1186/s12871-018-0574-9.

and performance (higher-order learning).[196] Their meta-analysis comprised 22 studies, 11 focused on knowledge and 11 on performance, systematically reviewing randomized controlled trials of the effectiveness of simulation-based teaching compared to other teaching methods, or no teaching, in medical students.[197] The various selective-fidelity training methods included "high and low fidelity mannequins, standardized patients, screen-based computer simulators, and human or animal cadavers."[198] The 22 studies involved 1,325 medical students from North America and Europe, divided into three groups: high-fidelity trained, low-fidelity trained, and a control group.[199]

Beal et al. found that high-fidelity simulation was no more effective than other teaching modalities at developing knowledge.[200] In addition, these researchers acknowledged that high-fidelity training methods are "resource- and faculty-intensive educational techniques" and, thus, generally cost more.[201] Consequently, lower-fidelity training methods could be beneficial. Since their research found that lower-fidelity options were efficacious, Beal et al. felt that teachers could employ low-fidelity devices to supplement traditional learning modalities and serve as a bridge between knowledge and performance.[202]

However, Beal et al. found that high-fidelity simulation was more effective than less-sophisticated and traditional modalities in performance development.[203] Participants who trained with high-fidelity simulation scored higher than those trained with either low-fidelity simulation or no stimulation (control group). In performance-based evaluations,

---

[196] Beal et al.

[197] Beal et al.

[198] Beal et al., 107.

[199] Beal et al.

[200] Beal et al.

[201] Beal et al., 110.

[202] Beal et al.

[203] Beal et al.

high-fidelity, simulator-trained students scored in the 99th percentile, while the control group scored in the 49th percentile.[204]

The researchers' finding that high-fidelity training methods improved performance better than lower-fidelity methods is consistent with the state-dependent learning concepts presented earlier in this thesis. Generally, higher-fidelity training simulators create a better learning environment that mirrors the real world, which can cultivate a better real-world performance.

3. Confidence

Although this thesis has primarily analyzed the efficacy of technology-based, selective-fidelity methods at improving performance in aviation and medicine, it appears these methods may improve something related to effective performance: confidence. According to Lucero and Chen, "One may be equipped with the right information and know how to use that information, but without confidence in the ability to enact that information, the associated behaviour may not take place."[205] Similarly, O'Donoghue et al. have offered that confidence impacts the "willingness and ultimate decision to act."[206] Thus, even though researchers have found that technology-based selective fidelity can improve competence, understanding how these methods can improve confidence is also noteworthy.

As detailed in this section, medical researchers have examined the impact of technology-based, selective-fidelity methods on confidence. In 2016, Chin et al. found that selective-fidelity training methods improved self-perceived confidence levels among otolaryngology medical residents.[207] Otolaryngology involves illnesses commonly

---

[204] Beal et al.

[205] Katie Stringer Lucero and Pan Chen, "What Do Reinforcement and Confidence Have to Do with It? A Systematic Pathway Analysis of Knowledge, Competence, Confidence, and Intention to Change," *Journal of European CME* 9, no. 1 (2020): 1, https://doi.org/10.1080/21614083.2020.1834759.

[206] Dara O'Donoghue et al., "Calibration of Confidence and Assessed Clinical Skills Competence in Undergraduate Paediatric OSCE Scenarios: A Mixed Methods Study," *BMC Medical Education* 18, no. 1 (December 2018): 211, https://doi.org/10.1186/s12909-018-1318-8.

[207] C. J. Chin et al., "Simulation-Based Otolaryngology—Head and Neck Surgery Boot Camp: 'How I Do It,'" *Journal of Laryngology & Otology* 130, no. 3 (March 2016): 284–90, https://doi.org/10.1017/S0022215115003485.

associated with the ear, nose, and throat, and while otolaryngologists treat most general conditions, otolaryngology surgeons treat cases requiring surgical intervention.[208] Chin et al. used a "boot-camp-style" approach to assess whether particular training methods, including high- and low-fidelity training devices, could improve confidence.

The one-day boot-camp experience consisted of three components: general technique training with low-fidelity devices, surgical training with high-fidelity simulators, and an interactive panel in which the participants discussed the standard triage and management of otolaryngologic emergencies.[209] The low-fidelity training devices included cadaveric simulation and human tissue replicas made from pig tissue to teach various procedures.[210] The researchers employed SimMan high-fidelity simulators to provide surgical intervention exercises. Chin et al. used these low- and high-fidelity devices to evaluate 10 emergency tasks, surgical and non-surgical, with the participants.

Through surveys, these researchers found that the boot-camp experience improved participants' confidence in performing these tasks.[211] The surveys showed that participants reported high confidence in all 10 emergency procedures, including intubation, bag-mask ventilation, and managing orbital hematoma and complex airway problems.[212] Thus, the Chen et al. study indicates that both low- and high-fidelity training methods can promote confidence while developing performance. According to experts in the field, improved confidence may be vital in demonstrating competence.

As a note, the Chin et al. study included an interactive panel in which the participants discussed the standard triage and management of otolaryngologic emergencies—a traditional teaching method. Although the study did not quantify the relative impact of each training component (i.e., low-fidelity methods, high-fidelity

[208] "Otolaryngology (ENT)/Head and Neck Surgery: Overview," Mayo Clinic, accessed March 12, 2022, https://www.mayoclinic.org/departments-centers/ent-head-neck-surgery/sections/overview/ovc-20424084; "What Is Otolaryngology?," Columbia University Department of Otolaryngology Head and Neck Surgery, accessed August 25, 2022, https://www.entcolumbia.org/about-us/what-otolaryngology.

[209] Chin et al., "Simulation-Based Otolaryngology."

[210] Chin et al.

[211] Chin et al.

[212] Chin et al.

methods, and the interactive panel) on the improved ratings, it is reasonable to believe that the interactive panel also imparted knowledge and contributed to the participants' higher confidence scores.

C. STANDARDS, POLICIES, AND REGULATIONS

As mentioned earlier, no single entity governs, regulates, and oversees the entire American healthcare system. For example, the Liaison Committee on Medical Education, a private organization recognized by the U.S. Department of Education, oversees medical school accreditation in the United States and Canada.[213] However, American hospitals adhere to the regulations and authority of four different U.S. federal agencies: the Departments of Justice, Treasury, Labor, and Health and Human Services.[214] Finally, even though all U.S.-licensed physicians must pass the United States Medical Licensing Examination, they must also pass individual state-level board examinations in the states where they practice medicine.[215] Thus, it is not surprising that the standards, policies, and procedures for selective-fidelity training methods vary widely in the U.S. medical field. The following subsections outline some of the agencies and organizations that provide standards and guidance for selective-fidelity training methods in the U.S. medical sector. Some entities focus on large sections of the healthcare industry while others cater to specific subsections.

1. The Society for Simulation in Healthcare

The Society for Simulation in Healthcare (SSH) is a private organization that strives to enhance medical performance and patient safety through accreditation, certification, knowledge sharing, and a directory of simulation centers. According to SSH, "Simulation

---

[213] "What Is LCME?," Augusta University, accessed August 25, 2022, https://www.augusta.edu/colleges/medicine/coffice/evaluation-services/lcme/index.php.

[214] "Federal Agencies with Regulatory or Oversight Authority Impacting Hospitals," American Hospital Association, October 2017, https://www.aha.org/system/files/2018-01/info-regulatory-burden-federal-agencies.pdf.

[215] "Board Certification Requirements," American Board of Medical Specialties, accessed August 25, 2022, https://www.abms.org/board-certification/board-certification-requirements/.

education is a bridge between classroom learning and real-life clinical experience."[216] In addition, the SSH seeks to advance simulation in healthcare through "education, professional development, and the advancement of research and innovation."[217] Ultimately, the SSH aspires to leverage simulation to improve the "quality of healthcare" globally.[218] In pursuit of that goal, in part, the SSH has accredited more than 100 healthcare simulation programs across various universities, hospitals, medical associations, and medical facilities.[219]

2. International Nursing Association for Clinical Simulation and Learning

The International Nursing Association for Clinical Simulation and Learning (INACSL), another private organization, believes that "simulation and innovation transform lives."[220] INACSL provides recommendations on standards and best practices in healthcare simulation and works to "promote research and disseminate evidence-based practice standards for clinical simulation methodologies and learning environments."[221] INACSL publishes *Clinical Simulation in Nursing*, a peer-reviewed monthly journal. Although INACSL does not offer accreditation services, the organization is intensely interested in three key areas of development within the simulation healthcare profession: "bridge the gap between education, practice, and research[;] . . . support design and innovation in simulation[;] . . . [and] foster professional development and leadership."[222] In pursuit of these goals, INACSL offers a simulation education program to develop nursing professionals.

[216] "Mission, Purpose, & Governing Documents," Society for Simulation in Healthcare, accessed August 25, 2022, https://www.ssih.org/Mission.

[217] Society for Simulation in Healthcare.

[218] Society for Simulation in Healthcare.

[219] Society for Simulation in Healthcare.

[220] "About INACSL," International Nursing Association for Clinical and Simulation Learning, accessed August 25, 2022, https://www.inacsl.org/about-inacsl.

[221] International Nursing Association for Clinical and Simulation Learning.

[222] "Strategic Map," International Nursing Association for Clinical and Simulation Learning, 2019, https://www.inacsl.org/assets/docs/Bylaws_and_Policies/INACSL_StrategicMap_vs5.0.pdf.

3. American College of Surgeons

The American College of Surgeons (ACS) is an accrediting organization that establishes standards for surgical education and training for "surgeons, surgical residents, medical students, and members of the surgical team using simulation-based education."[223] The ACS believes that simulation can increase patient safety.[224] Consequently, it seeks "new education and technologies, best practices, and research and collaboration" among its accredited institutions.[225] In 2020, Cooke et al. published an analysis of the ACS's best practices in simulation education. Between 2011 and 2019, the ACS accredited 247 institutions and developed 337 best practices that Cooke et al. assigned to seven categories: "approaches to faculty development, scholarly activity, development of curricula, use of resources, delivery of educational content, assessment of learners, and collaboration between centers."[226] According to Cooke et al., the ACS's best practices serve to promote excellence in surgical simulation.[227] Additionally, the ACS partners with the National Center for Collaboration in Medical Modeling and Simulation.

4. National Center for Collaboration in Medical Modeling and Simulation

The National Center for Collaboration in Medical Modeling and Simulation (NCCMMS) is a public–private endeavor. In 2001, the federal government funded the Eastern Virginal Medical School's Modeling, Analysis, and Simulation Center to partner with Old Dominion University. Together, these universities collaborated to establish a research center, the NCCMMS, which works to enhance patient care through medical modeling and simulation-based training and education for "healthcare students and

[223] "ACS Accredited Education Institutes: Setting the Standard of Excellence and Innovation," American College of Surgeons, accessed August 25, 2022, http://www.facs.org/education/accreditation/aei.

[224] American College of Surgeons.

[225] American College of Surgeons.

[226] James Cooke et al., "Overarching Themes from ACS-AEI Accreditation Survey Best Practices 2011–2019," abstract, *Surgery* 168, no. 5 (2020): 882–87, https://doi.org/10.1016/j.surg.2020.06.022.

[227] James M. Cooke et al., "Simulation Center Best Practices: A Review of ACS-Accredited Educational Institutes' Best Practices, 2011 to Present," *Surgery* 163, no. 4 (2018): 916–20, https://doi.org/10.1016/j.surg.2017.11.004; Cooke et al., "Overarching Themes from ACS-AEI Accreditation Survey."

practitioners."[228] The NCCMMS partners with various public, private, and academic entities.[229] As mentioned previously, the NCCMMS works closely with the ACS to provide its Medical Modeling and Simulation Database to the public.[230] This service is accessible via PubMed online and consists of searchable medical modeling and simulation studies.[231]

D. STRESS MITIGATION AND POST-TRAUMATIC STRESS DISORDER TREATMENT

Stress is inescapable. In some ways, stress focuses the mind and improves performance.[232] However, in many ways, stress inhibits performance.[233] The search for stress mitigation techniques to improve performance is not new. For example, centuries-old religious practices used to calm the mind serve as the basis for modern-day diaphragmatic breathing.[234] Other contemporary techniques include mental rehearsal, goal setting, and positive self-talk.[235] These are all cognitive tools. However, physical tools can be helpful, and some have found ways to employ certain selective-fidelity training devices to mitigate stress.

For example, the medical field utilizes VR training to reduce stress in at least two unique situations. First, researchers have shown how VR devices reduce anxiety effectively and increase patients' sense of control before and after first-time procedures. Second,

---

[228] "About NCCMMS," National Center for Collaboration in Medical Modeling and Simulation, accessed August 25, 2022, https://medicalmodsim.com/about-us/.

[229] National Center for Collaboration in Medical Modeling and Simulation.

[230] National Center for Collaboration in Medical Modeling and Simulation.

[231] "Medical Modeling and Simulation Database," National Center for Collaboration in Medical Modeling and Simulation, accessed August 25, 2022, https://medicalmodsim.com/mmsd/.

[232] Pietrangelo.

[233] Pietrangelo.

[234] Sung-Hee Han et al., "Effect of Immersive Virtual Reality Education before Chest Radiography on Anxiety and Distress among Pediatric Patients: A Randomized Clinical Trial," *JAMA Pediatrics* 173, no. 11 (2019): 1026, https://doi.org/10.1001/jamapediatrics.2019.3000.

[235] W. P. P. Stream, "How to Emulate Elite Athletes and Navy SEALs to Reach Peak Performance," *Medium* (blog), October 27, 2016, https://medium.com/@WPPStream/how-to-emulate-elite-athletes-and-navy-seals-to-reach-peak-performance-6d1a530ec11b.

researchers have demonstrated how VR can help post-traumatic stress disorder (PTSD) sufferers. This section briefly discusses both.

Whether diagnostic (e.g., x-ray) or surgical (e.g., appendectomy), first-time medical procedures can produce uncontrollable stress in some patients. Uncontrollable stress can create feelings of "helplessness" or a sense of being overwhelmed.[236] Uncontrollable stress can produce harmful effects after a procedure—for example, longer recovery times, worse pain, and anxiety.[237] Moreover, children generally have less experience dealing with stress and fewer coping mechanisms. Therefore, it was unsurprising that Han et al. observed uncontrollable stress among some pediatric patients.[238] This research team employed a VR training regime before a particular first-time diagnostic medical procedure to lessen anxiety and increase a sense of control.

In this research study, patients participated a mere three-minute VR experience that reduced anxiety and increased a sense of control. Before the procedure, the researchers provided a virtual tour to the pediatric patients in which an animated guide accompanied the patient's avatar. This guide avatar explained the procedure, urged deep breathing, and asked for cooperation.[239] The VR experience effectively provided a realistic virtual tour of the procedure environment and an overview of the procedure itself (see Figure 11).[240] Pre-and post-procedure surveys indicated that these pediatric patients better managed stress and anxiety while undergoing chest x-rays.[241] Thus, the researchers associated the decreased anxiety and stress with increased "familiarity and exposure to the strange environment through VR education."[242]

---

[236] Roselinde Henderson et al., "When Does Stress Help or Harm? The Effects of Stress Controllability and Subjective Stress Response on Stroop Performance," *Frontiers in Psychology* 3 (June 2012), https://www.frontiersin.org/article/10.3389/fpsyg.2012.00179.

[237] Judith K. Wells et al., "Presurgical Anxiety and Postsurgical Pain and Adjustment: Effects of a Stress Inoculation Procedure," *Journal of Consulting and Clinical Psychology* 54, no. 6 (1986): 831–35, https://doi.org/10.1037/0022-006X.54.6.831.

[238] Han et al., "Effect of Immersive Virtual Reality Education."

[239] Han et al.

[240] Han et al.

[241] Han et al.

[242] Han et al.

Figure 11. VR Experience of the Radiography Room[243]

Another form of stress is PTSD. Although multiple definitions exist, according to the Mayo Clinic, PTSD is "a mental health condition triggered by a terrifying event—either experiencing it or witnessing it."[244] Treating patients with PTSD takes many forms. Cognitive behavioral therapy (CBT) is one of the traditional treatments for PTSD.

CBT consists of various interventions, one being exposure therapy. An individual can receive a one-on-one discussion-based exposure therapy session.[245] During this session, individuals are exposed to the "trauma memory" in a controlled and safe setting with the aid of "mental imagery, writing, or visits to places or people that remind them of their trauma."[246] Then, with the help of a psychotherapist, the individual learns to adjust one's perspective of the trauma, reduce associated fear and anxiety, and desensitize oneself to the traumatic memory. This process is gradual.[247]

---

[243] Source: Han et al, 1028.

[244] "Post-traumatic Stress Disorder (PTSD): Symptoms and Causes," Mayo Clinic, accessed August 25, 2022, https://www.mayoclinic.org/diseases-conditions/post-traumatic-stress-disorder/symptoms-causes/syc-20355967.

[245] "Cognitive Behavioral Therapy," Mayo Clinic, March 16, 2019, https://www.mayoclinic.org/tests-procedures/cognitive-behavioral-therapy/about/pac-20384610.

[246] "Treatment & Facts: Post-traumatic Stress Disorder (PTSD)," Anxiety and Depression Association of America, accessed August 25, 2022, https://adaa.org/understanding-anxiety/posttraumatic-stress-disorder-ptsd/treatment-facts.

[247] Anxiety and Depression Association of America.

However, since as early as 1999, psychotherapists have used VR to construct CBT sessions to treat PTSD, and its use has grown.[248] Research into the efficacy of VR PTSD treatment has followed with positive results. Multiple studies have found the use of VR to be a worthwhile treatment for PTSD. A 2019 meta-analysis by Kothgassner et al. found that VR exposure treatment reduced extreme emotions and decreased depression associated with PTSD.[249] Gonçalves et al. and Eshuis et al. have found VR treatment efficacious in treating PTSD.[250]

As a result of VR's immersive quality, controllability, and repeatability, it is not shocking that the technology has successfully treated PTSD. By its very nature, VR is immersive and can transport a person back to a highly representative facsimile of one's initial traumatic experience. Control during exposure therapy is essential. With VR, either the psychotherapists or patients can instantly stop the VR experience. This control increases feelings of safety. Finally, patients can easily repeat VR exposure therapy sessions. Repeated realistic exposures allow individuals to gradually decrease their fear and anxiety associated with an event because it becomes familiar, and eventually, the negative emotions degrade or ultimately abate.[251]

---

[248] Barbara Olasov Rothbaum et al., "Virtual Reality Exposure Therapy for PTSD Vietnam Veterans: A Case Study," *Journal of Traumatic Stress* 12, no. 2 (April 1999): 263–71, https://doi.org/10.1023/A:1024772308758.

[249] Oswald D. Kothgassner et al., "Virtual Reality Exposure Therapy for Posttraumatic Stress Disorder (PTSD): A Meta-Analysis," *European Journal of Psychotraumatology* 10, no. 1 (2019): 1654782, https://doi.org/10.1080/20008198.2019.1654782.

[250] Raquel Gonçalves et al., "Efficacy of Virtual Reality Exposure Therapy in the Treatment of PTSD: A Systematic Review," *PLoS One* 7, no. 12 (2012): e48469, https://doi.org/10.1371/journal.pone.0048469; L. V. Eshuis et al., "Efficacy of Immersive PTSD Treatments: A Systematic Review of Virtual and Augmented Reality Exposure Therapy and a Meta-Analysis of Virtual Reality Exposure Therapy," *Journal of Psychiatric Research* 143 (November 2021): 516–27, https://doi.org/10.1016/j.jpsychires.2020.11.030.

[251] Kothgassner et al., "Virtual Reality Exposure Therapy."

IV. CONCLUSION

The aviation, medical, and law enforcement professions share many similarities. For example, pilots, medical practitioners, and police officers often contend with uncertainty, complexity, information deficiency, and mortal risks. The aviation and medical sectors improve performance in part with selective-fidelity training methods. This study examined how the law enforcement training community might leverage those methods to improve training and performance.

A. FINDINGS

Based on the findings of this thesis, the law enforcement training community should use both low- and high-fidelity training but employ select methods based on the underlying learning objective. For example, they should use high-fidelity training methods to develop higher-order learning and stress mitigation techniques and consider using high-fidelity training devices in the treatment plan for officers who have PTSD. Conversely, trainers should use low-fidelity training methods—which can be less costly—to develop lower-order learning, such as checklist responses. In addition, based on the research, law enforcement trainers should employ high-fidelity training methods to improve performance in novel situations. There appears to be a carry-over phenomenon whereby high-fidelity training methods may promote better performance in unpredictable encounters.

Furthermore, based on the analysis conducted in this study, the law enforcement community should use high-fidelity training devices as a bridge to reality-based training (RBT); emphasize deliberate breath, refined focus, and controlled attention techniques in technology-based, selective-fidelity training methods; and develop confidence in trainees. Finally, the law enforcement training community should look to the medical sector's system as a guide to establish standards, policies, and procedures surrounding selective-fidelity training methods.

1. Low- and High-Fidelity Devices

Researchers have found that devices from both ends of the fidelity spectrum can be efficacious. Therefore, law enforcement trainers should employ a wide range of these tools, spanning tablet-based games to immersive VR devices. For example, in aviation, trainers employ low-fidelity simulators to develop basic flight skills and multi-million-dollar motion-based simulators to hone intermediate and advanced skills. In medicine, trainers use low-fidelity mannequins to teach CPR and high-fidelity VR experiences to practice brain surgeries.[252] Thus, law enforcement trainers should confidently use both low- and high-fidelity training devices. Ultimately, the underlying learning objective and the requisite level of fidelity should guide a law enforcement trainer's choice between lower- and higher-fidelity training options.

Law enforcement trainers should incorporate high-fidelity training options when developing advanced learning objectives and accept the potentially higher costs associated with these devices. Research shows that more-sophisticated options like VR devices and advanced simulators can better develop higher-order learning (i.e., apply, analyze, and evaluate from Bloom's taxonomy). Many upper-tier learning objectives are present during high-risk situations such as determining when to arrest someone, communicating with individuals suffering from mental health crises, and facing deadly force encounters. Due to their realism, immersive qualities, and repeatability, high-fidelity training devices offer an opportunity to develop higher-order learning objectives. Moreover, research from Chapters II and III indicate that these qualities combined can lead to improved real-world performance.

As a note, higher-fidelity training methods might carry higher costs, but their return on investment make them worthwhile. Specifically, these methods can be expensive, time-consuming (e.g., new curriculum and instructor development), and logistically burdensome (e.g., locations for use and storage). However, evidence shows these devices can improve real-world performance, possibly translating into lives saved for citizens and officers alike.

[252] Brian Fiani et al., "Virtual Reality in Neurosurgery: 'Can You See It?'—A Review of the Current Applications and Future Potential," *World Neurosurgery* 141 (September 2020): 291–98, https://doi.org/10.1016/j.wneu.2020.06.066.

Therefore, the potentially higher associated costs should not deter law enforcement policymakers and executives from investing in higher-fidelity training options.

However, lower-fidelity devices should also play an integral role in the training and development of police officers. Low-fidelity training options are especially beneficial regarding lower-order learning and stewardship of resources. Research from Chapters II and III indicate that lower-fidelity devices can assist in acquiring and recalling information (i.e., remember and know). Thus, law enforcement trainers should use lower-fidelity training methods to support learning basic academy content, including laws, policies, and procedures. For example, police trainers could employ phone- or tablet-based programs to teach rote information like municipal ordinances and state statutes to police recruits during their academy training.

Furthermore, law enforcement professionals can demonstrate effective stewardship by selecting a lower-fidelity option—which can be less costly, time-consuming, and resource intensive—when a higher-fidelity option is unnecessary. For example, some departments may mandate how police officers script their introduction and initial verbiage during vehicle stops. Academy recruits or newly graduated rookie officers could easily use an inexpensive phone- or tablet-based game to help them memorize this verbiage as opposed to VR trainers.

Another place for low-fidelity training is checklists. Law enforcement is chock-full of checklists, and police trainers should use low-fidelity training devices to teach checklist material. Aviation research has demonstrated that low-fidelity simulators can help develop checklist recall. Within law enforcement, a wide variety of situations benefit from completing a checklist. On the extreme end, a checklist can help responding police officers prioritize their efforts during an active-shooter incident, for example. By prioritizing the safety of those involved with a hierarchical checklist—such as the one for victims, bystanders, police, suspects—officers can reduce complexity and provide a framework for strategies and tactics to resolve a crisis.[253] In a more mundane setting, a checklist can help

[253] "NTOA Tactical Response and Operations Standard," National Tactical Officers Association, accessed August 25, 2022, https://www.ntoa.org/swat-standard/.

officers ensure their equipment is present and functional before each shift (e.g., firearms loaded and tasers properly functioning).

2. Novel Situations

Technology-based, selective-fidelity training methods found in aviation and medicine may better prepare police officers to perform in novel situations. As presented in Chapter II, aviation researchers found that these training methods endowed most students with the skills to address unpredictable situations effectively. Furthermore, in the same chapter, the Miracle on the Hudson account offered a real-world example of this phenomenon—Captain Sullenberger had never experienced a scenario like the one he faced in his years of simulation training, yet he developed a successful solution, in part, because of that training. In each of these instances, there appeared to be a carry-over effect of simulated training. In other words, these training methods allowed individuals the ability to craft creative solutions to novel situations. One reason for this phenomenon may be that simulated training, particularly high-fidelity training, provides individuals the opportunity to experience stressful and risky encounters, thereby building a toolbox of complex problem-solving skills and stress management techniques along the way. Consequently, they have an effective framework for cognitive processing and physical performance when facing a real-world, novel situation.

The law enforcement training community should utilize high-fidelity training methods to strengthen police officers' ability to contend with novel situations The law enforcement profession consists of encounters involving unpredictability, information deficiency, and complexity. Law enforcement trainers cannot duplicate every encounter in the learning environment—time, money, and resources are limited. Yet, the benefit of simulated training is twofold: it prepares police officers for conceivable encounters and helps to develop intuitive skills to cope with inconceivable circumstances. The latter can be challenging in many ways. Invariably, these situations can be inherently stressful, and stress can inhibit creative thought. However, high-fidelity simulated training can help police officers cope with the stress and craft inventive solutions, leading to improved performance in novel situations.

3. Stress and PTSD

Law enforcement trainers should take advantage of simulators and VR devices to inculcate stress management techniques and help officers suffering from PTSD recover. As discussed in Chapters II and III, researchers found that technology-based, selective-fidelity training methods are efficacious at developing stress management skills and assisting in PTSD treatment. By using certain training devices, student pilots learned to better manage stress in both the learning environment and actual flight, patients developed skills to reduce stress and anxiety during actual procedures, and those suffering from PTSD learned effective coping strategies. Based on the analysis of this research study, simulators and VR devices might better prepare police officers for stressful encounters and potentially treat PTSD.

In that pursuit, law enforcement trainers should incorporate high-fidelity training options such as sophisticated simulators and VR devices to expose police officers to stressful encounters. Research shows that exposure to stress teaches people how to manage and mitigate it. By extension, such exposure is likely to be effective at teaching police officers to manage the stress associated with violent interactions, vehicle pursuits, and deadly force encounters. Many police officers have reported experiencing stress and certain physiological reactions (e.g., tunnel vision, auditory exclusion, and increased respiration) during critical or serious incidents. Moreover, some police officers have shared how stress and physiological responses impaired their performance—they focused on the stress in lieu of the problem in front of them. Therefore, employing high-fidelity training methods can help police officers mitigate stress, improve performance, and save lives during critical incidents.

Additionally, law enforcement policymakers should consider high-fidelity training options to assist police officers in coping with PTSD and potentially assess officers' fitness for duty after a critical incident. In the aftermath of some critical incidents, police officers can experience mild or severe PTSD. As shown in Chapter III, researchers found that simulators and VR devices can help patients suffering from PTSD by providing them with a progressively stressful, repeatable, and highly controllable experience—all critical components of effective treatment. Thus, the treatment plan for a police officer recovering from a critical incident could include training sessions consisting of virtual encounters that gradually become more stressful. Each phase of stress management and mitigation training could be repeated, and, most importantly, the virtual training sessions could be stopped immediately, if needed.

Technology-based, selective-fidelity training methods might even help determine an officer's fitness for duty. Sometimes, police officers need a leave of absence after a critical incident. Police officers could give themselves and their department's executives confidence that they are ready to return to duty by performing well in a high-fidelity virtual evaluation program.

4. High-Fidelity Methods as a Bridge to RBT

Law enforcement trainers should use high-fidelity training methods as a bridge to the most realistic training options because advanced students often require the most authentic experiences to develop their skills. The U.S. Navy learned this when assessing the benefits of high-fidelity training among their intermediate- and advanced-level pilots to determine whether simulated flight training could replace actual flight training. Both intermediate and advanced pilots derived benefits from simulated training. However, the most-advanced pilots benefited most from actual flight training. The researchers concluded that experience trumped highly simulated experience, but high-fidelity training methods seemed to serve as an effective bridge to real-world experience (in this case, actual flight).

Accordingly, law enforcement trainers should work to utilize high-fidelity training methods as bridges to RBT—the most realistic training option available for law enforcement—with its realistic scenarios, live role players, and projectile-based weapons. Bloom's taxonomy indicates that learning is progressive, so basic knowledge may be not only a foundation for advanced understanding or performance but also a prerequisite. Thus, police trainers should deliberately develop training programs that begin with low-fidelity simulators, proceed to VR devices, and culminate with RBT experiences to enhance real-world performance.

5. Breath, Focus, and Attention

Law enforcement trainers should aim to incorporate the practice of intentional breath control, refined focus, and controlled attention with technology-based, selective-fidelity training methods. Research presented in Chapter II has shown that these practices in combination with simulated training may improve performance. For example, during one flight-simulator training program, students performed better when they controlled their respiration, guided their focus, and directed their attention. Similarly, Captain Sullenberger described how his years of simulator training and these practices during the emergency landing of Flight 1549 contributed to his success. Furthermore, each of these examples involved higher-order learning, so law enforcement trainers should purposely incorporate the practice of breath control, refined focus, and controlled attention when developing higher-order learning during simulator and VR training.

6. Confidence

The law enforcement training community should seek to enhance confidence with technology-based, selective-fidelity training methods. Research presented in Chapter III indicated that even low-fidelity training methods can promote confidence. Moreover, confidence can have a direct impact on performance. Law enforcement professions encounter critical situations daily that require sound decision-making and prompt action. This research study reviewed the real-world failure of decision-making and action in Parkland, Florida. Consequently, the law enforcement training community should seek to leverage all available opportunities to develop police officers' confidence. A police officer who has received such training may have not only the knowledge of what to do but also the confidence to do it.

7. Standards, Policies, and Procedures

Ideally, the law enforcement training community should pursue a system for developing and establishing standards, policies, and procedures surrounding the use of technology-based, selective-fidelity training methods like those used in the medical industry. This recommendation stems from a commonality between the medical and law enforcement sectors: decentralization. The medical industry involves a wide range of generalists and specialists practicing medicine in various settings, including private practices and non-profit hospitals; myriad institutions providing initial and continuing education; and numerous organizations, from local to state to federal, that govern and regulate the medical profession. Similarly, the law enforcement profession consists of a broad spectrum of agencies, including public and private organizations providing initial and continuing education and, again, numerous agencies, from local to state to federal, that govern and regulate the law enforcement profession. However, as the research presented in Chapter III indicates, the medical sector's decentralized system has allowed some entities to emerge as recognized leaders in establishing standards, policies, and procedures related to technology-based, selective-fidelity training methods and devices. Consequently, it may be advantageous for law enforcement to pursue a similar approach.

Currently, multiple law enforcement institutions provide general industry-wide recommendations for various aspects of law enforcement. Suppose these agencies could lead in guidance and administration related to standards, policies, and procedures pertaining to technology-based, selective-fidelity training methods. In that case, the entire sector could benefit from better training uniformity. Numerous law enforcement institutions could serve this role: the International Association of Chiefs of Police, the Major City Chiefs Association, the Police Executive Research Forum, the International Law Enforcement Educators and Trainers Association, or the International Association of Directors of Law Enforcement Standards and Training.

Although the aviation industry's uniform standards, policies, and procedures are effective, law enforcement's decentralization does not lend itself to this top-down approach. The FAA oversees nearly every aspect of aviation in the United States, allowing for uniformity of standards, policies, and procedures. This oversight includes technology-based, selective-fidelity training methods. Research presented in Chapter II shows how this system provides for industry-wide continuity; more consistent, effective training; better sharing of educational lessons learned; and, ultimately, increased safety. Even though the present-day law enforcement community is divided by various jurisdictional lines, striving for a singular regulatory body that unifies the standards, policies, and procedures surrounding technology-based, selective-fidelity training methods could prove greatly beneficial.

B. FUTURE RESEARCH

Future research efforts could focus on several relevant topics. Fortunately, thousands of police professionals receive initial and ongoing training annually, representing the opportunity for adequate sample sizes for future research studies.

Curriculum design can be instrumental in the effectiveness of an education program. The narrow focus of this thesis did not include an examination of curriculum components like the ideal timing, frequency, and quantity of technology-based, selective-fidelity training methods. Thus, research into this topic might assist law enforcement trainers in designing effective curricula.

Another research study evaluating the effectiveness of technology-based, selective-fidelity training devices in the marketplace would be insightful. The law enforcement simulator and VR marketplace currently consists of numerous devices. The trial-and-error method may be the only way for some law enforcement trainers to compare the quality and effectiveness of certain devices, but this process is inherently inefficient and does not promote responsible public-sector stewardship. Therefore, research examining the efficacy of particular devices in the marketplace could result in better training and stewardship of limited public resources.

This study found that technology-based, selective-fidelity training methods can improve law enforcement training and performance. These additional research studies present an opportunity not only to further enhance law enforcement performance but also to reduce controversy surrounding some police encounters, cultivate better public trust and community relations, and, most importantly, save lives—of citizens and police officers alike.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

AeroCorner (blog). "The Differences between Types of Flight Simulators Explained." Accessed August 25, 2022. https://aerocorner.com/blog/types-of-flight-simulators/.

Alinier, Guillaume. "A Typology of Educationally Focused Medical Simulation Tools." *Medical Teacher* 29, no. 8 (January 2007): e243–50. https://doi.org/10.1080/01421590701551185.

Allen Interactions. "Using Selective Fidelity in Immersive Learning Systems April 30, 2020." Streamed live on April 30, 2020. YouTube video, 56:10. https://www.youtube.com/watch?v=MMC1bYOykVk.

American Airlines. "American Airlines Marks the 10th Anniversary of the 'Miracle on the Hudson.'" January 15, 2019. https://news.aa.com/news/news-details/2019/American-Airlines-Marks-the-10th-Anniversary-of-the-Miracle-on-the-Hudson/default.aspx.

American Board of Medical Specialties. "Board Certification Requirements." Accessed August 25, 2022. https://www.abms.org/board-certification/board-certification-requirements/.

American Civil Liberties Union. *Fighting Police Abuse: A Community Action Manual*. New York: American Civil Liberties Union, 1997. https://www.aclu.org/other/fighting-police-abuse-community-action-manual.

American College of Physicians. "Critical Care Medicine." Accessed June 16, 2021. https://www.acponline.org/about-acp/about-internal-medicine/subspecialties-of-internal-medicine/critical-care-medicine.

American College of Surgeons. "ACS Accredited Education Institutes: Setting the Standard of Excellence and Innovation." Accessed August 25, 2022. http://www.facs.org/education/accreditation/aei.

American Hospital Association. "Federal Agencies with Regulatory or Oversight Authority Impacting Hospitals." October 2017. https://www.aha.org/system/files/2018-01/info-regulatory-burden-federal-agencies.pdf.

Andrews, Dee Howard, Lynn A. Carroll, and Herbert H. Bell. "The Future of Selective Fidelity in Training Devices." *Educational Technology* 35, no. 6 (1995): 32–36. https://www.jstor.org/stable/44428304.

Anxiety and Depression Association of America. "Treatment & Facts: Post-traumatic Stress Disorder (PTSD)." Accessed August 25, 2022. https://adaa.org/understanding-anxiety/posttraumatic-stress-disorder-ptsd/treatment-facts.

Apex Officer. "VR Police Training Platform." Accessed August 25, 2022. https://www.apexofficer.com/platform.

Armstrong, Patricia. "Bloom's Taxonomy." Vanderbilt University, 2010. https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/.

Artwohl, Alexis. "Perceptual and Memory Distortions during Officer Involved Shootings." Skokie, IL: Americans for Effective Law Enforcement, 2008.

Augusta University. "What Is LCME?" Accessed August 25, 2022. https://www.augusta.edu/colleges/medicine/coffice/evaluation-services/lcme/index.php.

Batchelor, Amanda, and Allison Cubillos. "Former BSO Deputy Scot Peterson Permitted to Visit Parkland School to Prepare for Trial." WPLG Miami, January 28, 2022. https://www.local10.com/news/local/2022/01/28/former-bso-deputy-scot-peterson-permitted-to-visit-parkland-school-to-prepare-for-trial/.

Beal, Matthew David, John Kinnear, Caroline Rachael Anderson, Thomas David Martin, Rachel Wamboldt, and Lee Hooper. "The Effectiveness of Medical Simulation in Teaching Medical Students Critical Care Medicine: A Systematic Review and Meta-Analysis." *Simulation in Healthcare* 12, no. 2 (April 2017): 104–16. https://doi.org/10.1097/SIH.0000000000000189.

Bellis, Mary. "History of Flight: The Wright Brothers—Invention of the First Powered, Piloted Airplane." ThoughtCo, July 3, 2019. https://www.thoughtco.com/history-of-flight-the-wright-brothers-1992681.

Benedictine University. "Miller's Pyramid of Assessment." n.d.

Binkley, Jeremiah, Michael Moreno, and Ronald Zenga. *Minimum NSS to Select Rotary* Wing. EMBA Project Report. Monterey, CA: Naval Postgraduate School, 2008.

Borovac, Josip Anđelo, Domenico D'Amario, Josko Bozic, and Duska Glavas. "Sympathetic Nervous System Activation and Heart Failure: Current State of Evidence and the Pathophysiology in the Light of Novel Biomarkers." *World Journal of Cardiology* 12, no. 8 (August 2020): 373–408. https://doi.org/10.4330/wjc.v12.i8.373.

Bradley, Paul. "The History of Simulation in Medical Education and Possible Future Directions." *Medical Education* 40, no. 3 (March 2006): 254–62. https://doi.org/10.1111/j.1365-2929.2006.02394.x.

Brewer, Nathan. "Your Engineering Heritage: Antoinette and Early Flight Simulation." IEEE-USA InSight, November 13, 2019. https://insight.ieeeusa.org/articles/history-early-flight-simulation/.

Buehler, Emily D. *State and Local Law Enforcement Training Academies, 2018—Statistical Tables*. NCJ 255915. Washington, DC: Bureau of Justice Statistics, 2021.

Campaign Zero. "Training." Accessed August 25, 2022. https://www.campaignzero.org/train.

Chin, C. J., C. A. Chin, K. Roth, B. W. Rotenberg, and K. Fung. "Simulation-Based Otolaryngology—Head and Neck Surgery Boot Camp: 'How I Do It.'" *Journal of Laryngology & Otology* 130, no. 3 (March 2016): 284–90. https://doi.org/10.1017/S0022215115003485.

Columbia University Department of Otolaryngology Head and Neck Surgery. "What Is Otolaryngology?" Accessed August 25, 2022. https://www.entcolumbia.org/about-us/what-otolaryngology.

Cooke, James, Alexis Thomas-Perez, Deborah Rooney, Catherine Sormalis, Robert Rege, and Ajit K. Sachdeva. "Overarching Themes from ACS-AEI Accreditation Survey Best Practices 2011–2019." Abstract. *Surgery* 168, no. 5 (2020): 882–87. https://doi.org/10.1016/j.surg.2020.06.022.

Cooke, James M., Deborah M. Rooney, Gladys L. Fernandez, and David R. Farley. "Simulation Center Best Practices: A Review of ACS-Accredited Educational Institutes' Best Practices, 2011 to Present." *Surgery* 163, no. 4 (2018): 916–20. https://doi.org/10.1016/j.surg.2017.11.004.

Covelli, Javier M., Jannick P. Rolland, Michael Proctor, J. Peter Kincaid, and P. A. Hancock. "Field of View Effects on Pilot Performance in Flight." *International Journal of Aviation Psychology* 20, no. 2 (2010): 197–219. https://doi.org/10.1080/10508411003617888.

Cox, Chelsey. "Fact Check: Officer Fired for Failing to Act during Parkland School Shooting Got His Job Back." *USA Today*, May 15, 2020. https://www.usatoday.com/story/news/factcheck/2020/05/15/fact-check-parkland-officer-who-failed-act-shooting-gets-job-back/5194831002/.

Cruz-Neira, Carolina, Daniel J. Sandin, and Thomas A. DeFanti. "Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE." In *SIGGRAPH93: Proceedings of the 20st Annual Conference on Computer Graphics and Interactive Techniques*, 135–42. New York: Association for Computing Machinery, 1993. https://doi.org/10.1145/166117.166134.

Darack, Ed. "How Did Microsoft Make Flight Simulator Seem So Real? *Air & Space Magazine*, April 2021. https://www.airspacemag.com/flight-today/flight-box-180977303/.

Eshuis, L. V., M. J. van Gelderen, M. van Zuiden, M. J. Nijdam, E. Vermetten, M. Olff, and A. Bakker. "Efficacy of Immersive PTSD Treatments: A Systematic Review of Virtual and Augmented Reality Exposure Therapy and a Meta-Analysis of Virtual Reality Exposure Therapy." *Journal of Psychiatric Research* 143 (November 2021): 516–27. https://doi.org/10.1016/j.jpsychires.2020.11.030.

Federal Aviation Administration. "FAA Approved Aviation Training Devices (ATDs)." May 28, 2021. https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs800/afs810/media/FAA_Approved_Airplane_ATDs.pdf.

———. "FAA Issues New Flight Simulator Regulations." April 14, 2016. https://www.faa.gov/news/updates/?newsId=85426.

———. "National Simulator Program (NSP)." Accessed August 25, 2022. https://www.faa.gov/about/initiatives/nsp/.

Fiani, Brian, Frank De Stefano, Athanasios Kondilis, Claudia Covarrubias, Louis Reier, and Kasra Sarhadi. "Virtual Reality in Neurosurgery: 'Can You See It?'—A Review of the Current Applications and Future Potential." *World Neurosurgery* 141 (September 2020): 291–98. https://doi.org/10.1016/j.wneu.2020.06.066.

FRASCA Flight Simulation. "Piper Archer Flight Simulation Training Device." Accessed August 25, 2022. https://www.frasca.com/products/piper-archer/.

Ghosh, Sanjib Kumar. "Human Cadaveric Dissection: A Historical Account from Ancient Greece to the Modern Era." *Anatomy & Cell Biology* 48, no. 3 (September 2015): 153–69. https://doi.org/10.5115/acb.2015.48.3.153.

Godden, D. R., and A. D. Baddeley. "Context-Dependent Memory in Two Natural Environments: On Land and Underwater." *British Journal of Psychology* 66, no. 3 (August 1975): 325–31. https://doi.org/10.1111/j.2044-8295.1975.tb01468.x.

Gonçalves, Raquel, Ana Lúcia Pedrozo, Evandro Silva Freire Coutinho, Ivan Figueira, and Paula Ventura. "Efficacy of Virtual Reality Exposure Therapy in the Treatment of PTSD: A Systematic Review." *PLoS One* 7, no. 12 (2012): e48469. https://doi.org/10.1371/journal.pone.0048469.

Goodreads. "Archilochus Quotes." Accessed August 24, 2022. https://www.goodreads.com/quotes/387614-we-don-t-rise-to-the-level-of-our-expectations-we.

Han, Sung-Hee, Jin-Woo Park, Sang Il Choi, Ji Young Kim, Hyunju Lee, Hee-Jeong Yoo, and Jung-Hee Ryu. "Effect of Immersive Virtual Reality Education before Chest Radiography on Anxiety and Distress among Pediatric Patients: A Randomized Clinical Trial." *JAMA Pediatrics* 173, no. 11 (2019): 1026–31. https://doi.org/10.1001/jamapediatrics.2019.3000.

Hazlett, Bill. "LAPD Training Project: Police Know How to Shoot—When Is Now the Issue." *Los Angeles Times*, November 20, 1974.

Henderson, Roselinde, Hannah Snyder, Tina Gupta, and Marie Banich. "When Does Stress Help or Harm? The Effects of Stress Controllability and Subjective Stress Response on Stroop Performance." *Frontiers in Psychology* 3 (June 2012): 179. https://www.frontiersin.org/article/10.3389/fpsyg.2012.00179.

Henry, Amanda. "A Brief History of Simulation Training." Industrial Training International, January 18, 2018. https://www.iti.com/blog/a-brief-history-of-simulation-training-.

Henson, Stacey. "Former Parkland Deputy Scot Peterson Charged after Staying Outside Marjory Stoneman Douglas School Shooting." *USA Today*, June 4, 2019. https://www.usatoday.com/story/news/nation/2019/06/04/marjory-stoneman-douglas-resource-officer-charged-staying-outside-school-shooting/1343721001/.

Hille, Karl B. "Better than Reality: NASA Scientists Tap Virtual Reality to Make a Scientific Discovery." National Aeronautics and Space Administration, January 29, 2020. http://www.nasa.gov/feature/goddard/2020/scientists-tap-virtual-reality-for-discovery.

History. "Wright Brothers." November 13, 2020. https://www.history.com/topics/inventions/wright-brothers.

Inc. "Captain Sully's Minute-by-Minute Description of the Miracle on the Hudson." March 6, 2019. YouTube video, 12:22. https://www.youtube.com/watch?v=w6EblErBJqw.

International Association of Chiefs of Police. "Home Page." Accessed September 14, 2022. https://www.theiacp.org/.

International Association of Directors of Law Enforcement Standards and Training. "Home Page." Accessed September 14, 2022. https://www.iadlest.org/.

International Association of Directors of Law Enforcement Standards and Training and Council of State Governments Justice Center. *The Variability in Law Enforcement State Standards: A 42-State Survey on Mental Health and Crisis De-escalation Training*. Eagle, ID: International Association of Directors of Law Enforcement Standards and Training, 2017.

International Nursing Association for Clinical and Simulation Learning. “About INACSL.” Accessed August 25, 2022. https://www.inacsl.org/about-inacsl.

———. “Strategic Map.” 2019. https://www.inacsl.org/assets/docs/Bylaws_and_Policies/INACSL_StrategicMap_vs5.0.pdf.

Jones, Felipe, Carlos Eduardo Passos-Neto, and Odonne Freitas Melro Braghiroli. “Simulation in Medical Education: Brief History and Methodology.” *Principles and Practice of Clinical Research Journal* 1, no. 2 (2015): 46–54. https://doi.org/10.21801/ppcrj.2015.12.8.

Josephs, Leslie. “‘Miracle on the Hudson’ Pilot Urges Simulator Training for the Boeing 737 Max.” CNBC, June 19, 2019. https://www.cnbc.com/2019/06/19/miracle-on-the-hudson-pilot-urges-boeing-737-max-simulator-training.html.

Josselyn, Sheena A., and Susumu Tonegawa. “Memory Engrams: Recalling the Past and Imagining the Future.” *Science* 367, no. 6473 (2020): eaaw4325. https://doi.org/10.1126/science.aaw4325.

Judy, Aaron, and Thomas Gollery. “U.S. Navy Pilot Competence: An Exploratory Study of Flight Simulation Training versus Actual Aircraft Training.” *Journal of Applied Social Science Research and Practice* 1 (2019): 4–33.

Kim, Jong W., Christopher Dancy, Benjamin Goldberg, and Robert Sottilare. “A Cognitive Modeling Approach—Does Tactical Breathing in a Psychomotor Task Influence Skill Development during Adaptive Instruction?” In *Augmented Cognition. Enhancing Cognition and Behavior in Complex Human Environments*, edited by Dylan D. Schmorrow and Cali M. Fidopiastis, 162–74. Lecture Notes in Computer Science. Cham: Springer International Publishing, 2017. https://doi.org/10.1007/978-3-319-58625-0_11.

Kleinert, Robert, Nadine Heiermann, Patrick Sven Plum, Roger Wahba, De-Ha Chang, Martin Maus, Seung-Hun Chon, Arnulf H. Hoelscher, and Dirk Ludger Stippel. “Web-Based Immersive Virtual Patient Simulators: Positive Effect on Clinical Reasoning in Medical Education.” *Journal of Medical Internet Research* 17, no. 11 (November 2015): e263. https://doi.org/10.2196/jmir.5035.

Koglbauer, Ioana. “Simulator Training Improves Pilots’ Procedural Memory and Generalization of Behavior in Critical Flight Situations.” *Cognition, Brain, Behavior* 20, no. 4 (December 2016): 357–66.

Kothgassner, Oswald D., Andreas Goreis, Johanna X. Kafka, Rahel L. Van Eickels, Paul L. Plener, and Anna Felnhofer. “Virtual Reality Exposure Therapy for Posttraumatic Stress Disorder (PTSD): A Meta-Analysis.” *European Journal of Psychotraumatology* 10, no. 1 (2019): 1654782. https://doi.org/10.1080/20008198.2019.1654782.

Kotler, Steven, and Jamie Wheal. *Stealing Fire: How Silicon Valley, the Navy SEALS, and Maverick Scientists Are Revolutionizing the Way We Live and Work*. New York: Harper Collins, 2017.

Levy, Alison. "Performance Beyond Fitness: Conditioning, Nutrition, Sleep and Stress Mitigation Are All Key to Maximizing Performance." *Firehouse*, April 2017.

Logan, Cheryl A. "Engrams and Biological Regulation: What Was 'Wrong' with Organic Memory?" *Memory Studies* 8, no. 4 (October 2015): 407–21. https://doi.org/10.1177/1750698015575189.

Lovell-Troy, Larry A. "Teaching Techniques for Instructional Goals: A Partial Review of the Literature." *Teaching Sociology* 17, no. 1 (January 1989): 28–37. https://doi.org/10.2307/1317922.

Lucero, Katie Stringer, and Pan Chen. "What Do Reinforcement and Confidence Have to Do with It? A Systematic Pathway Analysis of Knowledge, Competence, Confidence, and Intention to Change." *Journal of European CME* 9, no. 1 (2020): 1834759. https://doi.org/10.1080/21614083.2020.1834759.

Major Cities Chiefs Association. "Home Page." Accessed September 14, 2022. https://majorcitieschiefs.com/.

Mayo Clinic. "Cognitive Behavioral Therapy." March 16, 2019. https://www.mayoclinic.org/tests-procedures/cognitive-behavioral-therapy/about/pac-20384610.

———. "Critical Care." Accessed August 25, 2022. https://www.mayoclinic.org/departments-centers/critical-care/sections/tests-procedures/orc-20399607.

———. "Otolaryngology (ENT)/Head and Neck Surgery: Overview." Accessed March 12, 2022. https://www.mayoclinic.org/departments-centers/ent-head-neck-surgery/sections/overview/ovc-20424084.

———. "Post-traumatic Stress Disorder (PTSD): Symptoms and Causes." Accessed August 25, 2022. https://www.mayoclinic.org/diseases-conditions/post-traumatic-stress-disorder/symptoms-causes/syc-20355967.

Mazuryk, Tomasz, and Michael Gervautz. "Virtual Reality: History, Applications, Technology and Future." Vienna: Vienna University of Technology, 1999.

McClernon, Christopher K., Michael E. McCauley, Paul E. O'Connor, and Joel S. Warm. "Stress Training Improves Performance During a Stressful Flight." *Human Factors: Journal of the Human Factors and Ergonomics Society* 53, no. 3 (June 2011): 207–18. https://doi.org/10.1177/0018720811405317.

McLeod, Saul. "Context and State Dependent Memory." Simply Psychology, 2021. https://www.simplypsychology.org/context-and-state-dependent-memory.html.

Mercadante, Sebastiano, Cesare Gregoretti, and Andrea Cortegiani. “Palliative Care in Intensive Care Units: Why, Where, What, Who, When, How.” *BMC Anesthesiology* 18, no. 1 (December 2018): 106. https://doi.org/10.1186/s12871-018-0574-9.

Meyer, Stephen. “Context-Dependent Learning: How It Can Make Your Training Stick.” *Rapid Learning* (blog), November 7, 2012. https://rapidlearninginstitute.com/blog/context-dependent-learning/.

Murray, Ken. “Spotlight on Training: The Misunderstood Concept of ‘No Pain, No Gain.’” Police1, August 1, 2005. https://www.police1.com/archive/articles/spotlight-on-training-the-misunderstood-concept-of-no-pain-no-gain-1Dtz2QCcdfrIyQMr/.

Murray, Kenneth R. *Training at the Speed of Life*. Gotha, FL: Armiger Publications, 2004.

National Aeronautics and Space Administration. “A Safer Way to Space Walk.” February 27, 2004. https://www.nasa.gov/missions/shuttle/f_saferspacewalk.html.

National Center for Collaboration in Medical Modeling and Simulation. “About NCCMMS.” Accessed August 25, 2022. https://medicalmodsim.com/about-us/.

———. “Medical Modeling and Simulation Database.” Accessed August 25, 2022. https://medicalmodsim.com/mmsd/.

National Tactical Officers Association. “NTOA Tactical Response and Operations Standard.” Accessed August 25, 2022. https://www.ntoa.org/swat-standard/.

Naval Technology. “T-45A/C Goshawk.” June 8, 2000. https://www.naval-technology.com/projects/t45-goshawk/.

Northern Illinois University Center for Innovative Teaching and Learning. “Experiential Learning.” In *Instructional Guide for University Faculty and Teaching Assistants*. DeKalb: Northern Illinois University, 2012. https://www.niu.edu/citl/resources/guides/instructional-guide/experiential-learning.shtml.

Nunez, Kirsten. “Fight, Flight, or Freeze: How We Respond to Threats.” Heathline, February 21, 2020. https://www.healthline.com/health/mental-health/fight-flight-freeze.

O’Donoghue, Dara, Gail Davison, Laura-Jo Hanna, Ben McNaughten, Michael Stevenson, and Andrew Thompson. “Calibration of Confidence and Assessed Clinical Skills Competence in Undergraduate Paediatric OSCE Scenarios: A Mixed Methods Study.” *BMC Medical Education* 18, no. 1 (December 2018): 211. https://doi.org/10.1186/s12909-018-1318-8.

Orvis, Karin A., Jennifer C. Moore, James Belanich, Jennifer S. Murphy, and Daniel B. Horn. “Are Soldiers Gamers? Videogame Usage among Soldiers and Implications for the Effective Use of Serious Videogames for Military Training.” *Military Psychology* 22, no. 2 (2010): 143–57. https://doi.org/10.1080/08995600903417225.

Pietrangelo, Ann. “What the Yerkes-Dodson Law Says about Stress and Performance.” Healthline, October 22, 2020. https://www.healthline.com/health/yerkes-dodson-law.

Police Executive Research Forum. “Home Page.” Accessed September 14, 2022. https://www.policeforum.org/.

President’s Task Force on 21st Century Policing. *Final Report of the President’s Task Force on 21st Century Policing*. Washington, DC: Office of Community Oriented Policing Services, 2015.

Prince, Andrew. “Experience, Training Make for Smooth River Landing.” National Public Radio, January 16, 2009. https://www.npr.org/templates/story/story.php?storyId=99476650.

Radtke, Trudi, ed. *Cognitive Psychology*. Santa Clarita, CA: College of the Canyons, n.d.

Rahmi M. Koç Academy of Interventional Medicine, Education, and Simulation. “History of Simulation.” Accessed August 25, 2022. https://www.aimes.org/en/page/about-us/history-of-simulation.

Relias, Nina, and Madeline Rockhold. “Stress Well to Test Well? How Applying State Dependent Learning Can Lead to Better Test Results.” *Only Human 2.0* (blog), April 30, 2017. https://onlyhuman2.swanpsych.com/2017/04/30/stress-well-to-test-well-how-applying-state-dependent-learning-can-lead-to-better-test-results/.

Reweti, Savern, Andrew Gilbey, and Lynn Jeffrey. “Efficacy of Low-Cost PC-Based Aviation Training Devices.” *Journal of Information Technology Education: Research* 16 (2017): 127–42. https://doi.org/10.28945/3682.

Rheingold, Howard. *Virtual Reality*. New York: Touchstone, 1992.

Rothbaum, Barbara Olasov, Larry Hodges, Renato Alarcon, David Ready, Fran Shahar, Ken Graap, Jarrel Pair, et al. “Virtual Reality Exposure Therapy for PTSD Vietnam Veterans: A Case Study.” *Journal of Traumatic Stress* 12, no. 2 (April 1999): 263–71. https://doi.org/10.1023/A:1024772308758.

Savitz, Eric J. “Facebook’s VR Business Is Bigger Than You Think. And It Is Masking the Company’s True Profitability.” *Barron’s*, June 28, 2021. https://www.barrons.com/articles/facebooks-vr-business-is-bigger-than-you-think-and-it-is-masking-the-companys-true-profitability-51624895223.

Schoonenboom, Judith, and R. Burke Johnson. "How to Construct a Mixed Methods Research Design." *Kölner Zeitschrift für Soziologie und Sozialpsychologie* 69, no. Suppl. 2 (2017): 107–31. https://doi.org/10.1007/s11577-017-0454-1.

Schricker, Bradley C., Stephen A. Schricker, and Robert W. Franceschini. "Considerations for Selective-Fidelity Simulation." In *Proceedings of the Society of Photo-Optical Instrumentation Engineers*. Vol. 4367, *Enabling Technology for Simulation Science V*, edited by Alex F. Sisti and Dawn A. Trevisani, 62–70. Orlando: Society of Photo-Optical Instrumentation Engineers, 2001. https://doi.org/10.1117/12.440055.

Scientific American. "Computers Are Becoming Faster and Faster, but Their Speed Is Still Limited by the Physical Restrictions of an Electron Moving through Matter. What Technologies Are Emerging to Break through This Speed Barrier?" October 21, 1999. https://www.scientificamerican.com/article/computers-are-becoming-fa/.

Society for Simulation in Healthcare. "Mission, Purpose, & Governing Documents." Accessed August 25, 2022. https://www.ssih.org/Mission.

Space Center Houston (blog). "How NASA Uses Virtual Reality to Train Astronauts." September 25, 2018. https://spacecenter.org/how-nasa-uses-virtual-reality-to-train-astronauts/.

Stanford Report. "Media Monitor." May 11, 2005. https://news.stanford.edu/news/2005/may11/med-mmonitor-051105.html.

Stream, W. P. P. "How to Emulate Elite Athletes and Navy SEALs to Reach Peak Performance." *Medium* (blog), October 27, 2016. https://medium.com/@WPPStream/how-to-emulate-elite-athletes-and-navy-seals-to-reach-peak-performance-6d1a530ec11b.

Teslasuit (blog). "What is Haptic Feedback?" Accessed August 24, 2022. https://teslasuit.io/blog/haptic_feedback/.

Tulsa Police Department. "Become a Tulsa Police Officer." Accessed July 19, 2022. https://www.jointpd.com.

Tyng, Chai M., Hafeez U. Amin, Mohamad N. M. Saad, and Aamir S. Malik. "The Influences of Emotion on Learning and Memory." *Frontiers in Psychology* 8 (August 2017): 1454. https://doi.org/10.3389/fpsyg.2017.01454.

U.S. Army Combined Arms Center. *Enhancing Realistic Training: Delivering Training Capabilities for Operations in a Complex World*. Fort Leavenworth, KS: U.S. Army Combined Arms Center, 2016.

U.S. Navy. "Fighter Pilot." Accessed August 25, 2022. https://www.navy.com/flynavy.

Wells, Judith K., George S. Howard, William F. Nowlin, and Manuel J. Vargas. “Presurgical Anxiety and Postsurgical Pain and Adjustment: Effects of a Stress Inoculation Procedure.” *Journal of Consulting and Clinical Psychology* 54, no. 6 (1986): 831–35. https://doi.org/10.1037/0022-006X.54.6.831.

Wikipedia. S.v. “US Airways Flight 1549.” Last modified September 8, 2020. https://simple.wikipedia.org/wiki/US_Airways_Flight_1549.

Wild, Flint, ed. “What Is a Spacewalk?” National Aeronautics and Space Administration, July 27, 2020. http://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-a-spacewalk-k4.html.

Witheridge, Annamaria, Gordon Ferns, and Wesley Scott-Smith. “Revisiting Miller’s Pyramid in Medical Education: The Gap between Traditional Assessment and Diagnostic Reasoning.” *International Journal of Medical Education* 10 (2019): 191–92. https://doi.org/10.5116/ijme.5d9b.0c37.

Wollert, Terry N., and Jeff Quail. *A Scientific Approach to Reality Based Training*. Winnipeg: Three Pistols Publishing, 2018.

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California