Virtual Reality in Higher Education: A Case Study at The Air University's Squadron Officer College

by

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Abstract

For decades, constructivist educational theorists such as Dewey, Piaget, Vygotsky, Papert, and Bruner have advocated that for deep learning to occur, learners should have some type of experience related to the subject matter to be learned. A new generation of consumer technology – referred to by titles such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality, and Immersive Technology – offers the ability to use pre-determined "first-person experiences" as a tool for educational outcomes.

The investigator in this study examined the efforts of the US Air Force Air University's Squadron Officer College (SOC) in a quest to evaluate VR as a learning tool in the Professional Military Education (PME) sector of Higher Education. The researcher considered four questions related to the challenges, strategies to overcome challenges, opportunities, and practical applications for integrating Virtual Reality as a learning tool in the SOC education program.

The qualitative, intrinsic case study used the uniquely-designed 11-question instrument known as the Immersive Technology in Education Questionnaire (ITEQ) to gather data from 27 volunteer participants in the SOC Commander's "VR in Education Challenge." In addition to the 27 open-ended questionnaires, the researcher conducted 10 recorded semi-structured interviews of SOC Stakeholders who had participated in the VR in Education Challenge.

From analysis of the questionnaire and interview data, the researcher derived 13 overall themes to answer the 4 key research questions. These themes included Technology-based Challenges, Leadership-based Challenges, Curriculum-based Challenges, Faculty-based

Strategies to Overcome, Non-faculty-based Strategies to Overcome, *Phenomenon of VR* Opportunities, *Use Cases for VR* Opportunities, *Unique Stakeholder Group* Opportunities, Air Force-Wide Opportunities, *Status Quo* VR Applications, *In Extremīs* VR Applications, *In Sitū Impedientī* VR Applications, and *Opibus Humanis* VR Applications.

The researcher's recommendations for action included for higher education agencies to consider implementing a "technology incubator" approach for VR in Education and for developers to work toward building applications that facilitate educational experiences. The researcher promotes development of a specific multi-participant social learning platform to be known as the Virtual Reality Educational Experience (VReX) which engages multiple participants simultaneously in educational content. Additional areas for further research for both military and non-military settings were suggested.

Acknowledgements

I would like to acknowledge first, the mentors who have helped so much along this research journey: Dr. Frances Kochan, Chairperson of the dissertation committee, for enduring encouragement throughout the dissertation process, and Dr. Jung Won Hur, Committee Co-chair, for giving me the first opportunity to consider the field of Virtual Reality as an area of specialty (in spring 2014 as a student in her "Technology into Curriculum" course) – as well as helping uncover several opportunities to better explore the subject of VR in education. I also thank Dr. Ellen Reames and Dr. Linda Searby for their support as members of the dissertation committee along with Dr. Margaret Shippen as university reader. Dr. Fil Arenas' mentorship through conducting research within the Air Force educational arena was priceless; also, I thank him for connecting the project with the support inside SOC for the "VR in Education Challenge" – particularly the support of the SOC Commander and Commandant, Brig Gen Gerald Goodfellow. With an eye on encouraging innovation, Goodfellow eagerly invested in VR technology and approved personnel-hours, facility space, computers, and connectivity for building the Virtual Innovations Learning Lab. I also thank the squadron commanders, instructors, and staff members at SOC for their direct participation in the research activities.

I deeply thank my family (Rhonda, Brianna, & Bethany) who have been the "WHY" behind every challenge I've faced and every goal I've accomplished. Finally, I thank my mom, Ann, who always encouraged me to explore new ideas and to share them with others in the effort to encourage others to think beyond the "status quo."

Dedication

First, this is dedicated to the military veterans of times past and to the Non-commissioned Officer corps serving in uniform today. Both of these groups were exemplified uncommonly in one persona by First Sergeant José S. N. Crisostomo, our mentor and personal hero during the 2009 tour in Afghanistan, who at age 59 became the eldest US service member to be killed in action during U.S. and allied campaigns since 9-11. “Sergeant C” was voluntarily serving a 2-year “recall to active duty” tour after having been retired from the Army for 15 years during which he had lived life as a veteran and civilian leader in his community. He tendered the ultimate sacrifice of his life on August 18th, 2009, while leading the way for NATO supply lines to remain open during a scourge of suicide bomber attacks in and around Kabul. SGT C’s military service prior to retirement had already distinguished him as a highly decorated soldier: including two Bronze Stars with Valor for service in Vietnam as well as decoration for meritorious service during DESERT STORM. Those of us in Kabul who were friends, colleagues, and “battle buddies” of SGT C will forever be honored to have served with him and to this day, our life endeavors are inspired by his selfless devotion to duty. SGT C’s wife and immediate family remain in their hometown of Spanaway, Washington, and other relatives reside in the family’s original Chamorro hometown of Inarajan, Guam.

Secondly, this is dedicated to the “digital native” cadets, officer trainees, and junior officers who represent the future of officer leadership in the military profession, as exemplified by Air Force First Lieutenant Roslyn “Roz” Schulte, the first female Air Force Academy graduate to be Killed in Action (KIA) as a result of enemy attack and the first female recipient of the National Intelligence Medal for Valor. During our time in Afghanistan, Lt Schulte was an astute intelligence officer who worked hard to help the Afghan Security Forces develop more robust intelligence capabilities. While en route between Kabul and Bagram, along the mostly dirt & rubble path known as "Route Bottle," (the only viable land route between these two main cities), Lt Schulte's vehicle was ambushed by a roadside improvised explosive device, killing her along with a fellow contractor teammate and injuring two Afghan colleagues. The very meeting she was convoying to involved collaboration among nations in finding and sharing intelligence to thwart such insurgent attacks. Through daringly conducting her duties, despite acknowledged threats in the region, Lt Schulte demonstrated valor through her example. Lt Schulte was also awarded the Hawaii Medal of Honor in recognition of her sacrifices.

Thirdly, this is dedicated to those Prisoners of War/Missing in Action (POW/MIA) from previous wars – both accounted-for and unaccounted-for – and their families – as exemplified by Air Force Captain Lance P. Sijan, whose F-4 aircraft went down on the limestone cliffs of North Vietnam on November 9, 1967. Despite numerous life-threatening injuries including a concussion and broken femur, Sijan survived in the jungle while evading capture by enemy forces for weeks. After eventually being captured, escaping (twice), and being re-captured, Sijan was finally detained at the brutal "Hanoi Hilton" interrogation facility where he was subjected to the most barbaric conditions imaginable. Despite repeated ruthless torture to break his will, Sijan persevered as the gold standard of embodying the warrior's code of conduct. Though Lance gave the ultimate sacrifice on January 22, 1968, while in captivity, all other warriors confined there during the following years were sustained by Sijan's example of resilience. For his intrepid model of courage, Captain Sijan was posthumously awarded the Medal of Honor.

Today, in Sijan's honor, the U.S. Air Force Lance P. Sijan Leadership Award is presented annually by the Air Force Chief of Staff at the Pentagon's Hall of Heroes. Through the years, Lance's family, and in particular, his sister, Janine, has been closely involved in the presentation of the award. In June 2011, on the occasion of receiving the honor of the Air Force Lance P. Sijan Leadership Award, my family and I had the equally precious honor of getting to know Janine and have developed a kindred friendship with her over the past several years. To Janine: as we once discussed, our vision of having the virtual live image of Captain Lance Sijan engaging a real-time leadership discussion with tomorrow's leaders – while being joined by the virtual likeness of leaders like "SGT C," "Lt Roz," and others – is closer to becoming reality now than ever before. Through the advances that Air University has made in implementing Virtual Reality as a learning tool, perhaps in the near future, we'll be "seeing" and "hearing" from the avatar likeness of these brothers and sisters in arms as a means of passing along their experiences as opportunities to learn about authentic leadership and selfless service.

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List of Abbreviations

3D	Three Dimensions
ACSC	Air Command and Staff College
AFAMS	Air Force Agency for Modeling and Simulation
AFCLC	Air Force Culture and Language Center
AFMAN	Air Force Manual
AFRS	Air Force Recruiting Services
AGS	Army Gaming Studio
AR	Augmented Reality
AU	Air University
AWC	Air War College
BYOD	Bring Your Own Device
CG	Computer Generated
CPC	Counterproliferation Center
CSAT	Center for Strategy and Technology
DK1	Development Kit 1
DK2	Development Kit 2
DoD	Department of Defense
DSTS	Dismounted Soldier Training System
ELT	Experiential Learning Theory
FAA	Federal Aviation Administration

FPS	Frames Per Second
GCT	Game-Changing Technology
GPS	Global Positioning System
HMD	Head-Mounted Device
HTIL	Human-Technology Interface Laboratory
IOS	International Officer School
ISD	Instructional Systems Development
ITEQ	Immersive Technology in Education Questionnaire
JTIEC	Joint Training Integration and Evaluation Center
LVC	Live-Virtual-Constructive
MIT	Massachusetts Institute of Technology
MoCap	Motion Capture
MPERPG	Multi-Player Educational Role-Playing Game
MRI	Magnetic Resonance Imaging
NCE	Negotiation Center of Excellence
NTTR	Nevada Test & Training Range
NYU	New York University
QDAS	Qualitative Data Analysis Software
PACE	Public Affairs Center of Excellence
PC	Personal Computer
PDSA	Plan, Do, Study, Act
PME	Professional Military Education
PTSD	Post-Traumatic Stress Disorder

R&D	Research and Development
SOC	Squadron Officer College
SOS	Squadron Officer School
STEM	Science, Technology, Engineering and Math
TRADOC	Training and Doctrine Command (U.S. Army)
USAF	United States Air Force
USB	Universal Serial Bus
UT-IISC	University of Toledo Interprofessional Immersive Simulation Center
VE	Virtual Environment
VHIL	Virtual Human Interaction Laboratory
VILL	Virtual Innovations Learning Laboratory
VIRTSIM	Virtual Simulation
VR	Virtual Reality
VUCA	Volatile, Uncertain, Complex, Ambiguous
ZPD	Zone of Proximal Development

Chapter I: Overview of the Study

"No man's knowledge here can go beyond his experience."
- John Locke

Never before in human history – other than in dreams or imagination – has it been possible for a person to fully experience the phenomenon of first-person immersion in a place or time that is separated from one's present grounded reality. Prior to the advent of Virtual Reality (VR), the sensory inputs (sights, sounds, acceleration, etc.) generated and collected in one's immediate physical environment were the only veritable sources for defining an experience in "first-person" perspective. VR technology is designed to intentionally convince one's mind that "first-person" has been redefined to a different perspective from the "here-and-now." Technological advances and quantum-scale cost reductions in consumer electronics present us today with the ability to use this redefined "first-person" perspective to bring about progress in multiple spheres of life.

The domains of medical practice, communication, fine arts, architecture, engineering, history, commerce, performing arts, law, the sciences, cinema, psychology, and many other spheres of social interaction – particularly education – all serve to benefit from advances in technology generally labeled as "Consumer VR", "Immersive Technology", "Augmented Reality" (AR), and "mixed reality" (Schnipper, Drummond, Hamburger, Houston, et al., 2014). The most recent developments in VR & AR have arisen primarily due to consumer demand for a higher degree of realism among participants in the $90+ billion global video game market. Yet, these consumer technologies – offering the capability to redefine "first-person"– will offer benefits to human kind on a much broader scale than originally intended. Incidentally, society-at-large is only beginning to fathom the effects that these developments in Consumer VR & AR will offer in realms much wider than interactive entertainment due to new advances in technology and newly developed equipment and devices (Hamburger, 2014).

Emergent Context of Consumer Virtual and Augmented Reality

"What we're doing is building tools that amplify a human ability."

- Steve Jobs, "Insanely Great" conference 1980

Among these recent devices, the Oculus Rift VR head-mounted display (HMD) was the first device to offer promise to deliver on the long-awaited ambition of affordable high-quality consumer VR. The first development kit version of the Oculus Rift (known as DK1) began production in late 2012, and along with its successor kit, DK2, the Rift was used by thousands of independent software developers around the world to build the preliminary ecosystem of consumer VR applications. Inventor of the Oculus Rift, then 19-year-old Palmer Luckey, also became founder of Oculus VR, the initially Kickstarter.com crowd-funded company that pioneered the $350 Rift development kit. In July 2014, the small start-up became buttressed by the influence and resources of a Fortune 500 company when it was acquired by the global social media icon, Facebook Inc., for $2 billion (Forbes, 2014; Solomon, 2014). Oculus VR and parent, Facebook, further collaborated with Samsung in 2015 to produce another innovative consumer VR device known as Gear VR: a mobile device accessory that allows select smartphone models to be utilized as the nucleus of a mobile VR platform (Poeter, 2015). Other household name heavyweights including Google, Microsoft, Sony, HTC, Apple, PayPal, HBO, Netflix, Lionsgate Entertainment, Valve gaming, and dozens of other technology and media leaders have also taken an active part in developing device hardware, accessories, or other application content for a market that is estimated to generate as much as $150 Billion per year by 2020 (Hayden, 2015; Merel, 2015; Webster, 2015). Many of these new products and content development projects began entering the public marketplace in 2016, and the subsequent five years will likely be known as the era in which VR and AR, or Immersive Technologies, assumed a constructive role within society.

New Endeavor: Using Virtual Reality as an Educational Tool

Immersive Virtual and Augmented Reality are actually not new; the body of extant literature on computer-generated VR and AR has been developing since the 1980's and offers prodigious insight on the technical, mechanical, physiological, psychological and social aspects of immersive VR and AR (Badcock & Palmisano, 2015; Blascovich & Bailenson, 2011; Chertoff & Schatz, 2015; Dindar, Tekalp, & Basdogan, 2015; Furness et al., 2002; Jones, et al., 2015; Lanier, 1999; Lanier, 2007; Lee, 2012; Lawson & Riecke, 2015; Lewis, 2016; McMahan, Kopper, & Bowman, 2015; Stouffs, Janssen, Roudavski, & Tunçer, 2013; Templeman, Page, & Denbrook, 2015; Winn, 1993; Witmer & Singer, 1998). The existence of this broad scope of literature, in fact, provides a knowledge foundation to inform educators (and other professional fields) as this new generation of consumer VR & AR technologies starts to be employed as a common tool of practice. In the past, however, the per-apparatus cost to produce an adequate quality head-mounted device (HMD) was prohibitive for widespread consumer use in fields like consumer entertainment, personal communication or education. Accordingly, cheap VR experiences that are poor in quality have proven to be unacceptable. An example of a commercial failure demonstrating the futility of a low-quality HMD was Nintendo's Virtual Boy®, produced for $180 in the 1995-96 timeframe. The technology limitations at that price point at that time produced a poor quality of experience plagued by motion sickness and resulted in the company's second-lowest selling platform ever (Boyer, 2009).

Prior to the current wave of consumer technology advancements aimed at producing quality VR at a reasonable cost, the price to achieve a moderately compelling immersive experience had historically been in the thousands to ten-thousands of U.S. dollars per single-user device. Because of the high investment threshold, the primary realms in which VR and AR had resided for decades was among industries and groups who could afford the high initial investment. Thus, the defense modeling and simulation industry, aviation, medical research, niches within academic research & development, and high-end computer generated imagery (CGI) applications in segments of the entertainment industry (e.g. "motion capture") were the sectors who had previously been the primary users of immersive technologies. These unique fields, correspondingly, were also the originators of the aforementioned large body of extant research literature. With the per-user cost for high-quality immersive VR becoming comparable to that of other ubiquitous consumer electronics like smartphones and televisions, the quality of experience and price points have converged to enable the next phase, once the critical mass inevitably acquires VR capability. This next phase will involve determining how to employ immersive technologies – and more importantly – the resulting ability to use first-person perspective – as a tool in a broad range of fields including education. Within the literature, there is little that examines the challenges and opportunities of integrating immersive technology into the higher education learning environment or that collaboratively links VR as a tool to improve learning outcomes within an authentic "live" educational program. Likewise, extant research is deficient in the arena of linking specific educational and social sciences theories to the use of VR in education.

Identifying the Line of Inquiry

This research, conducted at the US Air Force Squadron Officer College, was an exploratory study to evaluate conceivable challenges and opportunities of integrating VR into higher education and to synthesize a collaboration of practical suggestions for using VR as a tool in the higher education learning environment. Within the framework of these conceivable challenges, opportunities, and practical suggestions for using VR, the exploratory study is grounded in the literature of educational and social science theories with particular foci on constructivist and experiential learning, situated cognition, critical thinking, flow theory, and educational games. The researcher chose to focus on these areas because his constituent field of practice is within the Professional Military Education (PME) sector. The above-mentioned concepts provide opportunity to deliver the PME sector a valuable theoretical foundation upon which to evaluate the proposition to invest and apply new education technology ventures. Also, examining this sector of higher education was in an effort to provide a final product with direct return to the researcher's sponsoring agency: the U.S. Air Force's Air University.

Statement of the Problem

For generations, educational theorists have professed that deep learning occurs best when learners actively participate in or have an experience as part of their learning activities (Brown, 1989; Bruner, 1982; Dewey, 1938; Friedman, 2005; Kolb, 2014; Lave & Wenger, 1991; Weigel, 2002; Winn, 1993). Given recent advances in consumer technology, virtual and augmented reality technologies present new opportunities for learners to engage with subject matter visually, audibly, and tactilely in "first-person" perspective – and thus to have a unique experience as part of the learning process. U.S. Air Force senior leadership has expressed a strong interest in investigating new technologies that have "game changing" potential application in education (James & Welsh, 2015). In light of these factors, the higher education field, and in particular, the Air University (responsible for all Air Force Professional Military Education – PME), has a need to be informed on the nature of VR and AR in order to better evaluate opportunities for investing in these technologies as learning tools. Likewise, the Curriculum Development and Instructional Delivery communities at large have a need to understand concrete ways that the new technologies can be used to effect desired learning outcomes.

Purpose of the Study

The aim of this research was to inform the Air University policy process, curriculum development efforts, and instructional practices on strategies to enhance and support the integration of VR into the graduate PME learning environment. The study sought to identify the elements that would be potential challenges, means to overcome challenges, and opportunities for integrating Immersive Technology into the learning environment and to synthesize a compilation of potential VR applications with relevance to PME with grounding in time-honored educational and social science theories. These challenges, opportunities, and applications should provide important foundational information for other higher education institutions seeking to use VR as a learning tool. Further purposes of the study were to provide a model that might be of value to others interested in using VR in the teaching process and to enhance the literature on this important topic.

The Air Force Instructional Systems Development Model

The formal model used by the Air Force for the development and evaluation of curriculum in education and training programs is known as the Instructional Systems Development (ISD) Model. Chapter 5 of the present study anchors the synthesis of research to the ISD model as a foundational tool for readers to interpret the study. From identifying the resources to be used in the study to evaluating the end results, the research has been interpreted through ISD in an effort to enable transferability to other higher education entities who employ ISD or a similar curriculum development model.

The Air Force originally adopted the ISD model in 1965, and through the years, four versions of ISD have evolved to incorporate a broader theoretical basis into instructional development. With the 1993 version of the ISD model, published in Air Force Manual 36-2234 (AFMAN 36-2234), the manual was written in a manner that leaves the model open and flexible for curriculum design and instructional delivery to be interpreted widely enough to fit the unique nature of any given education or training learning context. Thus, since 1993, the primary model has stood the test of time while the subordinate instructions, given in Air Force Handbook 36-2235, Volumes 1, 2, 3, 5, and 10, were all updated in 2002 to reflect field experience in implementing ISD (AFMAN 36-2234, p. 6-10). The ISD model was also designed with influences from the "Continuous Quality Improvement" school of thought.

The model in AFMAN 36-2234 is described in three stages as follows:

Figure 1. Instructional Systems Development – System Functions

The first stage of the model, "Management," includes the function of controlling and directing the development and operations of the instructional system. The concept of "Support," involves maintaining the overall system, while "Administration" relates to the daily record keeping and processing functions. "Delivery" is the active process of students being involved in the designed learning activities, and "Evaluation" relates to gathering operational, summative, and formative data that is provided back into the loop of assessing and evaluating the learning design to make improvements to instruction activities and result in future improved student performance.

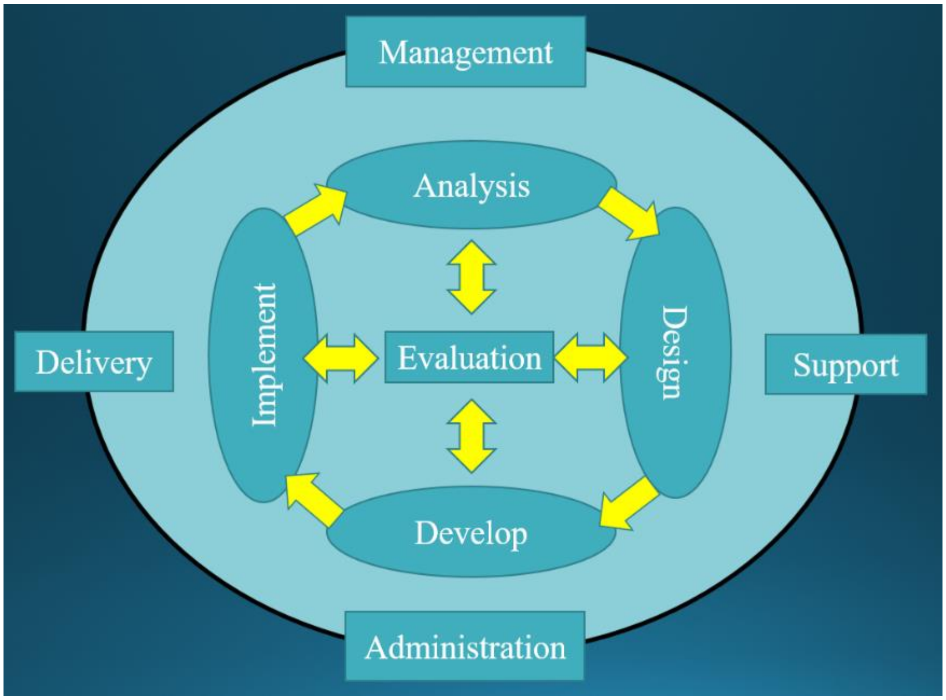

Figure 2. Instructional Systems Development – Phases of the Model

The second stage of describing the ISD model includes adding the phases of the process. The phases include “Analysis” in which it is determined what the need for instruction is. Next comes “Design,” in which the actual learning materials are identified. In the “Development” phase, the learning activities are made specific. “Implementation” relates to the active involvement of learners in the learning activities. At the core of the model remains the concept of “Evaluation” in which the continuous cycle of making the instructional system better is carried out through formative, summative, and operational evaluation. The concept of continuous quality improvement as added to the model is depicted in Figure 3, which incorporates the complete Air Force ISD model.

Figure 3. The Formal Air Force ISD Model

The key additional attribute to this phase of the model is that ISD is a continuous process in which all of the activities are taking place in an environment of quality improvement. Thus, while the individual components of the ISD model are working synchronously or even in parallel to each other, the entire process is subject to the rapid improvement cycle of Plan, Do, Study, Act (PDSA), which can result in modifying any individual activity or phase of the model based upon evaluation of data with the end result toward improving learning outcomes.

The Specific Research Setting

Based on the researcher's personally-identified criteria, the U.S. Air Force Squadron Officer College (SOC) at Maxwell Air Force Base, Montgomery, Alabama, was chosen by the researcher as the ideal fit for these criteria. Following is a list of the criteria including a brief explanation of how SOC fit the criteria specified:

1. Past organizational experience in Technology related to Virtual Environments: SOC won the 2013 Federal Virtual Challenge for the project, "The Compound," a Multi-Player Educational Role-Playing Game (MPERPG, pronounced "EMM-perg") which was recognized at the federal level for its ability to teach critical thinking and adaptability to graduate-level students. Likewise, SOC was the first-ever PME school to utilize the "Virtusphere," which in 2009 was state-of-the-art technology for exploring virtual environments.
2. Prior successful uses of Educational Technology: "The Compound" was a learning game developed at SOC that, in the 2012-13 timeframe, pushed the envelope on using Educational Technology for graduate-level learning. Also, SOC was an innovator for the Air University in implementing a "Bring Your Own Device" (BYOD) policy school-wide by providing WiFi connectivity throughout the SOC facility and enabling all students to connect wirelessly using their own mobile technology as their primary means of internet access.
3. A willing key informant available: SOC's architect of "The Compound," and the 2013 Federal Virtual Challenge award recipient on SOC's behalf was Dr. Fil Arenas, a professional colleague of the researcher. Dr. Arenas willingly agreed to further SOC's engagement in research on VR, and in July 2014, provided the introduction of the researcher to the senior leader of SOC, the Commander, (then) Colonel Gerald Goodfellow (promoted to brigadier general during the course of the research.) Dr. Arenas was also formally appointed by Auburn University to serve as a member of the dissertation committee for the present research.
4. Leadership and Stakeholder base that is receptive to new innovation: Goodfellow was known for incorporating innovation as a key value within SOC's organizational philosophy

and was eager for SOC to collaborate on research in VR. The Commander's eagerness to support the VR research was accompanied with full backing for Dr. Arenas to serve as agency informant for the study and serve as the overall leader of SOC's internal VR inquiry initiative, subsequently identified as the Commander's "VR in Education Challenge." In line with strong leadership support of innovation, stakeholders throughout the SOC milieu have historically been known within the PME community for innovative instruction techniques and delivery methods (Ritchie, 1950).

5. Capable of providing resources to support the endeavor (facility, funding, equipment): Goodfellow's support further included resources for equipping a laboratory – the Virtual Innovations Learning Laboratory (VILL) – dedicated to enabling collaborative inquiry in applying innovative technologies to the graduate learning environment. The VILL was built as part of the first phase of this research partnership during which the classroom space was equipped with twelve workstations that included Oculus Rift DK2 VR head-mounted displays (HMDs), suitably equipped PC computers, wireless commercial internet access, widescreen overhead projection capability, and associated accessories and furnishings to enable collaborative inquiry on VR for a group of up to 12 people simultaneously.
6. Geographic proximity/convenience to the researcher: Given that Maxwell AFB was within the researcher's immediate driving area and to Auburn University, the proximity provided convenience of access to SOC on a regular basis throughout the research study.
7. Personal acquaintance with the mission of the academic institution: The researcher is an alumnus of the Squadron Officer College's in-residence program (1998), and has been a guest speaker at SOC's "Warrior Resilience Symposium" in Polifika Auditorium (2012).

8. No direct formal relationship with the members of the institution: The researcher has never been in the organizational chain of command at SOC, and is not anticipated to become a part of the SOC chain of command in the future. This aspect served to avoid any type of undue command relationship influence in the collection of the qualitative data.

Integrating the Context of Problem, Purpose, ISD Model, and Setting

In addressing the overall research problem statement and the purpose of the study, the Air Force ISD model is integrated as a component of the overall research framework. Given that ISD is the model officially used by SOC (as well as other Air Force PME schools), by including the ISD model as part of the context of the study, the research results, conclusions, and recommendations may be more readily interpreted with applicability to PME curriculum development efforts by SOC and other Air Force PME institutions. Additionally, while this report was not a formal "Program Evaluation," the output product supports the central component of the ISD Model, "Evaluation," from the perspective of offering the researcher's synthesis of the evaluations and analyses provided throughout the study by a cross-section of SOC Stakeholders.

The problem statement and research purpose define the context for which the specific research questions are developed. As an intrinsic qualitative case study with a pragmatic focus, the questions in this study are developed to reveal the underlying narrative perspective of SOC Stakeholders on the subject of "VR in Education," and synthesize that narrative into an action-oriented body of suggested courses of action to inform Air University policy and instructional practices in the graduate PME arena.

Research Questions

Each of the following research questions begins with an overall theme, or central focus that groups the sub-questions into one of three primary areas – in essence: the challenges, opportunities, and practical applications of VR applied to Education at SOC.

1. Central focus: (Negatives & associated inverse positives) – Challenges and surmounting strategies anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

   Q1a. What are the potential challenges to integrating VR into the SOC learning environment?

   Q1b. What strategies/ideas could be used to overcome these potential challenges?

2. Central focus: (Positives) – Potential opportunities anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

   Q2. What are the potential opportunities for SOC in using VR as a learning tool?

3. Central focus: (Applications) – Practical applications of VR identified by SOC Stakeholders as having best potential to improve learning outcomes:

   Q3. What VR content (current or future applications) would have the most impact on SOC student learning?

Methodological Framework Overview

The aim of qualitative research is to seek out a deeper understanding of a particular process, phenomenon, or environment (Creswell, 2013; Yin, 2014). Approached from the paradigm of pragmatism, this qualitative, exploratory, intrinsic case study sought to harness collaborative inquiry conducted among SOC Stakeholders to demonstrate a better understanding of the nature of Virtual Reality technology and the potential that VR applications may have in the PME sector of higher education. The qualitative research methods used in this study are explained in detail in Chapter 3; what has been provided here is a brief description of those methods.

As part of SOC's program of integrating Virtual Reality technology, the college's Commander issued to select Stakeholders the Commander's "Virtual Reality in Education Challenge" in which SOC Stakeholders engaged in inquiry to examine how VR could be used in the SOC curriculum (further described in chapter 3 as well.) This approach of involving expert Stakeholders in investigating the future use of technology is grounded in Air Force tradition as Gen "Hap" Arnold, the first Air Force Chief of Staff relied upon synthesis of expert inputs to solve complex, uncertain problems. In 1944, Gen Arnold commissioned "Project Delphi," the precursor of the RAND Corporation, as a study relying upon the consensus of experts to identify likely future uses of airpower during the Cold War (Linstone & Turoff, 2002). Beyond its grounding in Air Force tradition, Stakeholder involvement in development of curriculum also has well-established precedence in adult & higher education (Linstone & Turoff, 2002; Hofer, 2006; Custer, 1999).

As part of the "VR in Education Challenge" program, a voluntary questionnaire of the participants was conducted. This questionnaire has been identified as the Immersive Technology in Education Questionnaire (ITEQ) – included at appendix 6. The researcher participated as subject matter expert in developing the ITEQ in coordination with the SOC key informant (discussion of this single-purpose instrument has been included in chapter 3.) The intent behind the ITEQ was to serve both as a practical tool to inform SOC on future VR curriculum development efforts as well as to later serve as a component of the present research. The SOC Commander, in coordination with the Air University Academic Affairs Office, determined to provide the SOC internally-administered ITEQ data to the researcher for analysis as part of the present research study (n = 27 open-ended questionnaires). Further, the researcher subsequently conducted interviews of SOC Stakeholders (n = 10 interviews) as additional qualitative data sources for the dissertation using the Semi-structured Interview Protocol as a baseline – included at appendix 7.

For data analysis, the ATLAS.ti Qualitative Data Analysis Software (QDAS) was used for coding of the amalgamated data from all questionnaires and interviews. Using the analysis of the questionnaire data, the researcher produced a summary to use as a supplementary reference during the semi-structured interviews. Again, in consultation with the SOC key informant, ten members who had participated in the Commander's "VR in Education Challenge" were selected for the semi-structured interviews which were audio recorded. Throughout the interviews, the researcher also took field notes. Subsequently, the interviews were transcribed and in the margins of the transcripts, the researcher's notes were added. Next, all transcript data were analyzed using ATLAS.ti tools from the perspective of synthesizing the data for answers to the primary research questions. (Data analysis has also been further described in chapter three.)

Triangulation of sources was considered as SOC Stakeholders from multiple constituencies were included in each phase of the data collection. Triangulation of methods was inherent in that beyond the 27 ITEQ questionnaires, 10 recorded transcribed semi-structured interviews were also used as data collection methods. Furthermore, analyst triangulation was ensured as the product of each data source's analysis was reviewed by a separate VR subject matter expert.

Significance of the Study

This study can be used as a model for higher education institutions who are interested in studying the process of integrating a new technology (such as VR) into their programs. Also, a key deliverable offered by the report is a synthesis of the ideas generated among dozens of professional instructors, curriculum developers, and educational leaders with regard to how VR can be used as a practical component in the learning process. Educators or other professionals who are inquiring about potential positive and negative aspects of implementing VR technology may find this aspect of the report a significant contribution to their inquiry. Since the study involved examining the establishment of the first-ever VR learning lab to use consumer VR in a leadership education arena, leadership development programs may also find the study to be value-added. The Virtual Innovations Learning Lab (VILL) became the "think-tank" used for investigating opportunities for using VR as a learning tool with particular emphasis on opportunities for experiential learning; thus, educational enterprises aspiring to magnify concentration on experiential learning through the use of VR may benefit from the conclusions as well.

Higher education programs interested in stakeholder involvement in curriculum design may also find value in the report's findings. The study used the VILL think-tank environment to collect qualitative data from Stakeholders who participated in the Commander's "VR in Education Challenge" using a unique questionnaire known as the Immersive Technology in Education Questionnaire (ITEQ). Though the questionnaire was developed with only this case in mind and as such did not undergo extensive validation studies, some readers may want to use the ITEQ instrument as a model in developing their own similar tool. Likewise, the protocol developed for the semi-structured interviews may provide value as research tools to others. Most importantly, however, the synthesis from among SOC Stakeholders of challenges, opportunities, and practical applications of VR offers to be the content to provide the most lasting and significant contribution.

This unique Stakeholder-involvement case study model for both researching the nature of a technology while simultaneously implementing the new technology into an organization can serve as a prototype for studying and implementing a new technology within the Air University's other colleges. Likewise, this Stakeholder-involvement case study model may also be of benefit to non-military institutions who endeavor to integrate a new technology (such as VR) into the learning process. Finally, the study should foster additional research on the important issues and strategies provided within it and on the specific findings being shared in the conclusion.

The Organizational Milieu of the Squadron Officer College

The U.S Air Force Squadron Officer College (SOC) is the Air Force's primary-level officer graduate Professional Military Education (PME) college. In this capacity, SOC educates all USAF captains and thousands of equivalent-grade civil service personnel as well as select captains from air forces of over 40 nations worldwide who partner with the USAF on military education programs. Historically, in any given single year, the college produced over 16,000 graduates of its in-residence and distance learning leadership development programs. All SOC students are college graduates (the vast majority with some post-graduate education and many with earned graduate or terminal degrees). SOC students have typically gained 4-10 years' practical experience as leaders in their chosen professional pathways. Such professional fields include pilots, attorneys, aircraft maintenance officers, doctors, scientists, chaplains, human resources officers, security forces officers, nurses and dozens of others. The age of SOC students is typically late-20's to early-30's.

In addition to SOC, the Officer Professional Military Education enterprise within the Air University also includes 2 other colleges, 3 schools, and 6 specialty centers: the Air War College (AWC: senior-level officer PME at 16+ years' service); Air Command and Staff College (ACSC: intermediate-level officer PME at 10-16 years' service); International Officer School

(IOS: lead-up school for international students planning to attend the other colleges); the School of Advanced Air and Space Studies (SAASS); the USAF Public Affairs Center of Excellence (PACE), the USAF Counterproliferation Center (CPC), the USAF Culture and Language Center (AFCLC), the USAF Negotiation Center of Excellence (NCE), the USAF Center for Strategy and Technology (CSAT), and the Teaching & Learning Center (TLC). Nearing the conclusion of the present research, the Air University was in process of standing-up the third Officer PME school known as the eSchool of Graduate PME which consolidated all the distance learning programs that had previously been administered by the above-mentioned colleges. Though a separate identity exists for each of these colleges, schools, and centers, an over-arching mission of Air Force Officer PME is to educate officers and equivalent grade civilians for national security leadership positions within the U.S. government and governments of U.S. allied nations.

The fundamental aim of SOC is to develop early to mid-career Air Force leaders who are critical thinkers. From a pedagogical standpoint, this means focusing on higher-order levels of learning. Siddique, et al. (2013), referred to Bloom's revised taxonomy in noting that when designing educational activities at the higher levels of learning, the cognitive domain focus is on Analyzing, Evaluating, and Creating. To achieve these higher levels of learning or critical thinking, the educational activities must go beyond lecture and standard teaching methods and, instead, concentrate on activities that require students to innovate and create. The present research focused on these higher levels of Bloom's taxonomy as the primary area where VR may provide original tools for learning.

The Call for Immersive Technology in Air Force Education & Training

Chief of Staff of the Air Force, General Mark A. Welsh, III, outlined a new strategic framework for the U.S. Air Force in a 2015 *Air and Space Power Journal* Senior Leader Perspective series article, "A Call to the Future." In the article, Gen Welsh provided perspective that gives impetus for Air Force PME to investigate the applicability of Immersive VR in the learning environment:

> *A Call to the Future* emphasizes two strategic imperatives—agility and inclusiveness—to position the Air Force for success in the coming decades … By embracing strategic agility, the Air Force will be able to move past the twentieth century's industrial-era processes and paradigms and be ready for the globally connected, information-based world of the coming decades. We will become more agile in the ways we cultivate and educate Airmen and in how we develop and acquire capabilities (p. 5).

The strategic agility referenced by Gen Welsh in regard to ways the Air Force educates Airmen gives top-level support for developing and acquiring a new capability like Immersive Technology. A more precisely targeted senior-level focus in support of considering Immersive Technology comes from the 2015 USAF Strategic Master Plan in which the Agility Goal titled "AG1.5" assigns the far-range (beyond 10 years) goal to the Air University to, "Preserve full-spectrum war-fighting, expeditionary, and combat support capabilities by … further integrating joint training (including Live/Virtual/Constructive) to offset reduced resourcing ..." (USAF Strategic Master Plan, p. 19). This guidance acknowledges the synergy available when combining "Live" education or training (the learner in live presence) with "Virtual" (the learner present in a virtual world), and "Constructive" (electronically fabricated avatars or "bots" and fabricated machines, places, live beings, etc.). The guidance further points toward this synergy having the potential for offering substantial resource savings to provide a strategic offset to reduced resourcing due to other commitments including low-intensity conflicts around the world that result in tighter constrained resources. The 2015 USAF Strategic Master Plan further defines a strategic vector to "Continue the Pursuit of Game-Changing Technologies" (USAF Strategic Master Plan, p. 59-63). This strategic vector, identified as "GCT," focuses on how the culture of the Air Force was forged from the outset with a spirit of innovation and a desire to explore the art of the possible. From the days of the Wright Brothers Flying School of 1910 to the Air Corps Tactical School before World War II, to the present-day Officer PME Transformation, the Air University and Maxwell Air Force Base have been built upon the nation's desire and the Air Force's predisposition to innovate and to exploit the advantages provided by technological progress.

In addition to top-level guidance from Headquarters Air Force, the Air University Strategic Plan clearly articulates the overriding value of exploring new technology capabilities like immersive technologies:

> The university must create the spaces—both physical and virtual—in which forward-thinking experts and advocates learn about, and share ideas on, the theory and practice of leadership and the application of airpower (AU Strategic Plan, 2015, p. 6).

By directly addressing the idea of "virtual space," the AU Strategic Plan directly acknowledges that learning activities not only will take place in virtual space, but it is the role of the university to develop and maintain this domain. The Strategic Plan goes on to articulate this role as a specific goal, Goal 5.1, which states, "Foster professional and effective learning and working environments: Investments in AU's virtual and physical environments yield a high return in performance and outcomes" (AU Strategic Plan, 2015, p. 19). This goal goes beyond suggesting the idea to investigate virtual environments, but further identifies the need to invest in virtual environments just as the university invests in physical environments. This goal is even delineated more precisely in a specific line of operation: “AU LINE OF OPERATION 5: BUILD CAPABILITY TO DELIVER AU PROGRAMS … 5.1.3 Ensure that the virtual learning and working environment is professional and effective for all university students and personnel” (AU Strategic Plan, 2015, p. 28).

This line of operation points toward an area that this dissertation investigated with regard to ensuring that the virtual learning and working environments are professional and effective. While virtual worlds have been used for various purposes, the topic this dissertation explores, which involves how immersive tools can be used more for educational purposes, has not been widely developed or explored. Primarily focused within the Squadron Officer College, the research directly supports the precepts articulated by the Air University Strategic Plan as well as the Air Force Strategic Master Plan and the Chief of Staff’s “A Call to the Future.”

The Air University (AU) Commander and President, Lt Gen Steven L. Kwast, related in the AU Transformation Vision a call for AU students to “… analyze and synthesize knowledge in ways that promote new perspectives and creative responses to emerging challenges…” Further, the Transformation Vision calls for “…graduates who are curious about the world they encounter and aggressive in seeking and leveraging learning opportunities.” (Air University Transformation Vision, p. 4). In a 2015 community presentation, Gen Kwast pronounced that, “We are moving away from the traditional brick-and-mortar classrooms where students listen to lectures and pass tests” (Burylo, 2015). By providing entirely new perspectives on visual, audio, and tactile educational content through 3-dimensional, 360-degree, stereoscopic visualization with capability for sound localization and tactile input and response, VR/AR technologies offer potential to deliver improved student outcomes within multiple domains of learning. In conjunction with widespread availability of broadband internet access and mobile networks that have come about over the past decade, the impending ubiquitous access to VR/AR technology – when appropriately applied to the field of education – provides promise to usher-in an entirely new era of collaborative access among students geographically separated across the globe. This collaboration among students in combination with the abundance of increased shared sensory input will offer improved learning outcomes for both “in-residence” and “distance learning” students. By offering new arenas for learning outcomes, Air University education programs will enable students worldwide to sharpen critical thinking skills within core competencies in ways that previously have not been possible.

Role of the Researcher

A degree of disclosure, or Heideggerian bracketing, of the researcher’s professional background, relation to the research population, and connection with the research topic is an important component to understanding the narrative within a qualitative exploratory case study (Tufford & Newman, p. 83). As an active duty colonel in the U.S. Air Force, the author of this dissertation, a doctoral student in Educational Leadership and Technology, was also an instructor at the Air War College’s Distance Learning Division from 2011 to 2013. Prior to serving at Air University, the author’s 20+ years of active duty service involved multiple levels of leadership in dozens of locations around the world in Mission Support career fields (Personnel, Services, Protocol, Education & Training, and Airbase/Bombing Range Logistics Support) to include command of a 1,200-person joint service combat support unit in Kabul, Afghanistan, which persevered through multiple insurgent attacks during his command. This experience provided the researcher with a standing of acceptance as a fellow warrior (or “insider”) among service members who were students, instructors, and educational leaders at SOC during the study. Likewise, the researcher’s recent PME faculty experience enabled him to be acknowledged as a knowledgeable “insider,” within the SOC faculty circle. Insider research is known as research in which the researcher operates within populations of which they are also considered members (Kanuha, 2000). This ability to be considered "a native" is important in qualitative inquiry, particularly during interviews due to the propensity for subjects to render acceptance to the interviewer and consequently be more likely to openly discuss their views on a subject. Lastly, the researcher not being a part of the subjects' formal chain of command – and his pledge of non-attribution – were additional factors that enabled subjects to feel at ease with speaking freely

Assumptions

Assumptions serve to qualify the scope of the study. The following assumptions were considered in the conduct of the research in this study:

1. SOC Stakeholders who participated in the ITEQ and the semi-structured interviews would provide their open, honest opinions and ideas without concern that they should "speak the party line" or just answer what was desirable.
2. The researcher's knowledge and experience would serve as an advantage to the research process more so than as a hindrance.

Limitations

Limitations serve to narrow the scope of the study. The following limitations were considered in the conduct of the research in this study:

1. The study only investigated VR integration efforts at the Squadron Officer College and transferability beyond that setting may be limited.
2. Subjects included only relevant Stakeholders of SOC; thus, transferability beyond that demographic group may be limited.
3. Participation in this study was voluntary; thus, qualitative inputs that may have been provided by non-volunteers would have naturally not been included in the results.

4. Qualitative open-ended questions were a part of the research; findings from them were not exhaustive and are not transferable to every situation.

Definitions of Key Terms

The 2015 foundational reference edited by K.S. Hale and K.M. Stanney, *Handbook of Virtual Environments: Design, Implementation, and Applications, Second Edition*, defines VR as follows:

> "Virtual Reality [or Virtual Environment, (VE)]: model of reality with which a human can interact, getting information from the model by ordinary human senses such as sight, sound, and touch and/or controlling the model using ordinary human actions such as position and/or motion of body parts and voice."

The key phenomenon upon which VR relies to build the sense of "being there" is the concept of "immersion." Hale and Stanney define this term as follows:

> "Immersion: the experience of being physically within a VE experience. ... See also *Presence*."

Thus, Immersive Technology provides the encounter of "being physically within" or "present" within the computer-generated virtual experience. Hale and Stanney's definition of "presence" is thus:

> "Presence: the illusion of being part of a virtual environment. The more immersive a VE experience, the greater the sense of being part of the experience."

While the literature usually references "presence" to imply one's manifestation within the virtual environment as opposed to one's physical "real world" environment, other authors allocate a more precise term, telepresence, to reference "a sensation unique to online environments, which causes users to feel they are part of the action" (Faiola et al., 2013; Novak, Hoffman, and Young, 2000). Thus, the terms presence and telepresence are often used interchangeably. Another apt definition is given by Witmer and Singer: "the subjective experience of being in one place or environment, even when one is physically situated in another. Experiencing the computer-generated environment rather than the actual physical locale." (Witmer & Singer, 1998)

Associated with VR is a related genre of technology known as Augmented Reality (AR) which often is synonymously referred to as "mixed reality." AR or mixed reality is similar to VR in that technology is used to present visual information to the user; however, the visual information presented by AR essentially "augments" the true reality that the user already sees, or "mixes" the real and virtual environments. An MIT Press article by Dr. Ronald T. Azuma provides a seminal analysis of Augmented Reality; in the article, Dr. Azuma explains:

> "AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it. Ideally, it would appear to the user that the virtual and real objects coexisted in the same space …" (Azuma, 1997)

Azuma's article also illustrates multiple arenas in which AR would be beneficial by providing the AR user with information that would not have already been readily available – known as intelligence amplification. An example of this would be, for instance, a delivery driver using AR to see clearly displayed addresses on each house or clearly mapped navigation guidance along the route without having to look down at a GPS. As VR and AR technologies become more readily available, determining how to take advantage of the technologies to provide intelligence amplification – particularly within education – will provide entirely new areas for potential research among scholars.

Virtual Reality Head-Mounted Display (HMD): A light-weight device that is worn like ski goggles on the user's head to deliver the user's eyes with a computer-generated field of vision while blanking out (though sometimes digitally recreating) the external environment. Also containing motion-tracking sensors that detect the precise location of the user's head in space, the goggles (worn simultaneously with lightweight headphones) provide the user a sense of being "present" in places other than the user's current "real world" location. The Oculus Rift Development Kit 2 (DK2) was the Virtual Reality HMD used during this research study.

In-residence Squadron Officer School (SOS): For SOC's in-residence school, every five weeks, 500+ students from Air Force installations around the world travel to Maxwell Air Force Base, Montgomery, Alabama, to attend the 5-week intensive leadership education program in-residence. The students stay in officer quarters at Maxwell (without families) and complete the intellectually and physically challenging leadership development experience. About 6,000 students per year are considered in-residence graduates of SOS. Instructors of the 5-week program are full-time faculty members of SOC in the rank of captain or major who are previous graduates of SOS and were selectively chosen to be instructors/mentors for subsequent courses of SOS in-residence. The SOC curriculum is developed by a permanent faculty including a combination of terminally-degreed civilian professors and senior ranking career officers and is produced in accordance with guidance from the Air Force and the US Department of Defense.

Virtual Innovations Learning Laboratory (VILL): The Leadership of SOC determined to develop a laboratory to enable faculty and students to research the newly developing field of consumer VR and evaluate ways that VR can be used in the SOC learning environment. This laboratory is equipped with 16 high-end graphics laptop PCs and 12 Oculus Rift DK2 Virtual Reality HMDs. The VILL was assigned to acquire additional future hardware equipment to provide a wider variety of VR experiences for further research. Also, curriculum development faculty members have been chartered to start investigating development of courseware using VR applied to the graduate PME environment.

Chapter One Summary

This chapter provided an overview of the study to include discussion on the unique opportunity provided to many fields of endeavor based on recent developments in the field of consumer Virtual Reality. The chapter described how the case of the US Air Force Squadron Officer College's efforts at integrating VR into their curriculum and providing qualitative inputs on the subject provided the intrinsic case study for the research. In the chapter, the research problem, purpose, and questions were outlined and the research methods used by the study briefly previewed. Chapter two, which follows includes a review of relevant literature. The third chapter provides greater detail on the research design and research methods used. Chapter four discusses results as applicable to each research question, and chapter five describes the author's conclusions, recommendations, and suggested future research opportunities.

Chapter II: Literature Review

This review of literature has been divided into five main parts and provides a synthesis of extant literature through the lens of considerations relevant to the overall research topic of "Virtual Reality in Higher Education: A Case Study at the Air University's Squadron Officer College." Part I provides a broad overview of prominent, long-standing educational and social science theories and concepts within which the use of Immersive Technologies in education may be explicably grounded. The second section provides analysis of the technical nature of immersive technology by drawing from literature to address key "what is it?" and "how does it work?" questions. Part III examines the biological sensory perception processes to reflect on how human senses work to make use of VR as an input to learning. A key focus of the present research was to identify specific applications for VR in higher education; thus, in part IV, various ways that VR has been applied generally in the past are highlighted: in private enterprise, in research endeavors, and in the military. The other overarching focus of the present research relates to challenges and opportunities of using VR in higher education, so Part V of the review demonstrates examples of challenges and opportunities of immersive technologies that are often manifest based on previous research. Extant peer-reviewed scholarly literature provided the core foundation for this chapter. In addition, due to the emergent and rapidly-developing nature of the subject matter, consideration was also given to broader industry periodicals and prominent online resources.

Educational/Social Science Theories Related to Immersive Technology in Education

Throughout Professional Military Education (PME), theories attributed to Dr. Benjamin S. Bloom, including learning domains, levels of learning, and the renowned "Bloom's Taxonomy" are used as benchmark frameworks for curriculum development and instruction. Those theories are presented first in this section. Next, Situated Cognition and Critical Thinking are examined as further educational concepts upon which PME and graduate education relies for theoretical grounding. From the field of positive psychology, the theory of "flow" and its connection to the principle of learning games was reviewed as additional models relevant to the practice of using immersive technologies in higher education. This general review of key educational theories closes with underscoring the related constructs of experiential learning and constructivism as the overarching paradigm that bridges each of the preceding educational theories to the use of VR and AR in higher education practice.

Bloom's taxonomy. Dr. Benjamin Bloom and colleagues' educational theories are deeply rooted as seminal guidance throughout all four service branches of the U.S. Department of Defense (DoD): particularly within graduate professional military education. Evidence of Bloom's influence can be seen in such authoritative documents as Air Force Manual 36-2234, Instructional Systems Development (November 1993), U.S. Army Training and Doctrine Command (TRADOC) pamphlet 350-70-7, Army Educational Processes (January 2013), Naval Education and Training Command 34-A, Navy Instructor Manual (August 2009), and the publication, Marine Corps Officer Professional Military Education Continuum (January 2011). Each one of these guiding documents illustrates examples of how the services broadly interpret educational systems development and delivery through a macro lens of Bloom's theories.

Dr. Benjamin Bloom, along with colleagues, Max D. Engelhart, Edward J. Furst, Walker H. Hill, and David R. Krathwohl, in 1956, published the first version of the classic taxonomy of educational objectives that has since served as an enduring theoretical model throughout the world of education. The first essential component of the taxonomy included the three domains: cognitive, affective, and psychomotor. The cognitive domain, which has subsequently been the realm in which the vast majority of formally-written educational objectives are focused, related to that which was primarily cerebral, or dealing with how the learner assimilates information mentally. The affective domain, which was subsequently further delineated in Krathwohl, Bloom and Masia's 1965, *Taxonomy of Educational Objectives, Handbook 2: Affective*, was concerned with the learner's emotions and attitudes and how those play a key role in the learning process. Finally, the psychomotor domain was the realm of the taxonomy that expressed the learner's physical manipulation of objects and tools as well as physical behaviors related to the learning environment. While Bloom, Krathwohl and colleagues did not originally express detailed levels of learning within the psychomotor domain, in 1975 scholar and student of Bloom, Ravindra H. Dave, produced a detailed taxonomy of the psychomotor domain (Dave, 1975).

Krathwohl and Bloom collaborated to produce a revised version of the taxonomy in 2000, in which the titles of all levels of learning were changed to verb forms and the hierarchical order among the higher levels of the cognitive domain were re-arranged to identify the highest level as "create" to acknowledge the act of creating new knowledge as essentially the highest form of learning. Based upon the combined works of Bloom, Krathwohl, Dave and others, the following figure shows the levels of learning within each primary domain as commonly referenced presently.

Table 1

Levels of Learning within the 3 Primary Domains of Bloom's Revised Taxonomy

Cognitive Domain	Affective Domain	Psychomotor Domain
Create	Characterized by Value Set	Embody
Evaluate	Organize	Articulate
Analyze	Value	Perfect
Apply	Respond	Manipulate
Understand	Receive	Imitate
Remember		

Adapted from: Bloom, Krathwohl, & Masia, 1984; Krathwohl, Bloom, & Masia,1984; and Dave, 1975

In the Air University Press publication, *Leveraging Affective Learning for Developing Future Airmen*, authors Tharp, Gould and Potter (2009), present a strong case to illustrate that the affective domain is the realm in which future instructional development can make tremendous gains toward improved learning outcomes. The authors further emphasized that educational technologies – specifically virtual environments – present a valuable opportunity toward tapping into the potential offered by the affective domain. "Virtual experiences can have a more profound influence on affective outcomes than other pedagogy because multiple senses (visual, auditory, and tactile) are involved" (Tharp, Gould, & Potter, 2009, pg. 21). Though at the time of publication (2009), the use of virtual environments in education were primarily limited to flat-screen 2-dimensional representations of 3D, Tharp, Gould, Potter, and other collaborators provided a precursor to the kinds of questions that the present research seeks to investigate. While the world of higher education had not yet been introduced to Immersive Virtual Reality via Head-Mounted Device when *Leverage Affective Learning…* was published, the authors' perspective shows support for ways future affective learning outcomes may be enabled by learning in VR: "They allow simulated experiences not possible in school settings, increase learner engagement by visually immersing students, support new forms of interaction and collaboration with the potential to increase students' knowledge and skills, and build self-efficacy." (Tharp, Gould, & Potter, pg. 21)

As articulated by Krathwohl and Bloom, the affective domain is the domain of learning in which human emotions or feelings are the determinant of educational outcomes. Given that an overarching purpose of PME is that of producing officers who are critical thinkers, just as in the cognitive domain where critical thinking is found at the higher levels of "analyze, evaluate, create," in the affective domain, critical thinking is also manifest at the higher levels. For the lower levels of the affective domain, "receive and respond," first, learners show indication of receiving the lesson information, and next provide emotion or behavior indicative of some emotional response to the lesson stimulus. Moving to the higher-order levels of learning within the affective domain, learners begin to "value" the learning objective by showing emotions or feelings that indicate empathy with the subject affect. Next, being able to "organize" these new feelings of empathy or subject emotions within the learner's own world view demonstrates the third level higher on the taxonomy. Lastly, the ability to "characterize" a value that is the subject of the curriculum is the highest level of affective learning (Krathwohl, Bloom, & Masia, 1984). This ability to "characterize" Air Force Core Values and to think critically through ethical decision-making using philosophies such as, "The Code of the U.S. Fighting Force," "The Airman's Creed," and principles from the "Law of Armed Conflict," as one's guide is at the fundamental core, arguably even the raison d'être of PME. Because VR technology's most universal application is that of making the user "feel a particular way" or to even "empathize" with a given situation, the likely applicability of VR as a learning tool within the higher levels of the affective domain are worthy of deliberate research and consideration for purposeful application. This ability of offering the foundation for higher-level critical thinking within the affective domain may be the unique pedagogical contribution of VR that has not been readily available previously as a tool for curriculum developers (Lee, Wong, & Fong, 2010; Riva, et al., 2007).

Situated cognition/situated learning. Situated cognition or situated learning suggests that learning is "situated," within the learner's mind based on the context where the learner works and applies the subject knowledge. In the natural environment and throughout most of organic human life, the vast majority of learning occurs in situational context with the content being learned. Yet, the majority of venues in which traditional higher education learning activities occur (i.e. classrooms, lecture halls, libraries) bear no association with the subject knowledge content. Principal exceptions to this notion include science & engineering laboratories, music conservatories, art studios, and teaching/learning hospitals. Aside from those exceptions, many traditional higher education learning venues are not situated – i.e. essentially abstract – with relation to the subject content. From the shadow of abstraction cast by a barren, un-related learning setting, higher education classroom & lecture hall learners constantly engage a challenging mental endeavor to overcome the abstraction created by the mundane setting. In the need to situate new learning into a mental pattern and build a mental context situated in time, place or social context with relation to the knowledge, classroom and lecture hall students expend a substantial amount of mental energy. Often, if materials for scaffolding through the abstract are not available, learning suffers. By providing some degree of relevance to the subject matter being learned within the learning environment, the visual cues can help situate the knowledge in the learner's mind (Lave &Wenger, 1991).

Social interaction is another key part of situated learning. Certain beliefs and practices are exhibited within a "community of practice" (Wenger, McDermott, & Snyder, 2002). As learners participate in the community of practice at the periphery, they gradually move to the "center" of the community: a process that Lave and Wenger refer to as "legitimate peripheral participation." Through participating in a community of practice, learners construct their own understanding of the authentic world. A concept labeled by John Seely Brown as "cognitive apprenticeship," involves the learner (apprentice) working within the community of practice under the tutelage of a learned coach (cognitive master) who takes an active role in the learner's quest – similar to the model traditionally used by trade guilds (Brown, 1989).

Another aspect of situated learning is that knowledge constructed in a situation that is relevant to the content becomes knowledge that is both more meaningful to and more successful for the learner (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991). This deeper, more relevant and successful learning can be accomplished through Virtual Reality (Winn, 1993). Virtual Reality provides a medium whereby a learner can be essentially transported to a place and time that has relevance to the content being learned. Being first-person in the new relevant situation, the learner engages in sights, sounds and tactile sensations that provide the impetus for situated learning to occur (Winn, 1993).

Critical thinking. "*Cogito ero sum" or "I think, therefore, I am"* (Descartes, 1644). Much of what adult learners think about, when left un-examined, is subject to bias, prejudice, distortion and misinformation. The concept of critical thinking stresses the importance of systematically examining one's own thinking – as well as examining the theories that are presented in the learning process. Elder, Paul, and Hiler's *Thinker's Guide Series* (2001), defines critical thinking as, "…the art of analyzing and evaluating thinking with a view to improving it" (p. 4). The authors describe important results of critical thinking to include: clearly formulating vital questions; using abstract ideas to assess relevant information; coming to tested and well-reasoned conclusions; using open-mindedness to assess assumptions and consequences; and using effective communication to solve and convey solutions to complex problems (Elder, Paul, & Hiler, 2001).

Particularly in the context of military leadership, critical thinking is a paramount skill to cultivate. A leader who can think critically is an essential output of graduate-level professional military education. Considering the continuously-changing nature of the operating environment for military leaders today, having tools to improve the process of thinking and make decisions becomes a strategic advantage. US Air Force Colonel W. Michael Guillot, in the 2003 Air and Space Power Journal article, *Strategic Leadership: Defining the Challenge*, notes three important aspects of the operating environment for military leaders that bestow particular importance to being able to think critically: “Consequential Decisions” (p. 70), “Performance Requirements” (p. 71), and “Volatility, Uncertainty, Complexity, & Ambiguity (VUCA)” (p. 72). While all decisions have consequences, the implications of strategic decisions made by military leaders have consequences that can effect alliances between nations or outcomes that can impact societies or alter the course of history. With regard to performance requirements, Guillot notes that an essential component of critical thinking is the ability for decisions to be precisely communicated. Strategic military decisions typically have long time horizons of 5, 10, or even 20 years; in such a length of time, if a strategic decision is well-reasoned, and conveyed with clarity, there is greater likelihood that performance of those involved in executing the decisions will be able to stay focused over the long term and result in achieving desired outcomes. Lastly, given the volatile, uncertain, complex, and ambiguous (VUCA) environment of strategic leadership in the military, leaders who check their thinking, examine their biases, and question their assumptions are more likely to be able to face VUCA situations and “penetrate the fog of uncertainty that hugs the strategic landscape" (Guillot, 2003, p. 72). Operating in a "system of systems" context such as within a multi-national alliance requires leaders to be able to think conceptually and be able to access implications of decisions as they are perceived by cultures, political systems, and world views completely different from one's own.

As generations of military thought leaders have advocated that developing critical thinking skills is the *sine qua non* of PME outcomes, any new innovation being introduced into the PME learning environment needs to be assessed in terms of whether it adds value to the process of developing critical thinking skills. VR as an innovation in the PME learning environment is no exception. Whether or not VR adds value to the process of developing critical thinking skills is a key subject the present study attempts to inform.

Flow Theory. The concept of "Flow" or "optimal experience" as proposed by architect of the theory, Mihaly Csikszentmihalyi (***mee**-hy **cheek**-sent-mə-**hy**-ee*), was originally described in 1975 as "a holistic sensation that people feel when they act with total involvement." (Fullagar & Kelloway, 2009, Csikszentmihalyi, 1975). Former head of the department of psychology at University of Chicago, Csikszentmihalyi and his colleagues have researched for decades on the question of what makes people happy and creative; the findings of this research provide the foundation of Flow Theory which is a core construct of positive psychology.

Flow research focuses on thousands of musicians, rock climbers, engineers, painters, dancers, and other experts who exercised their skills professionally or as a leisure activity and, surprisingly, given the wide diversity of activities and settings, the findings demonstrate remarkable consistency in descriptions of the flow experience. In Csikszentmihalyi's 1990 seminal work, *Flow: The Psychology of Optimal Experience,* he further describes flow as:

> "…the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it" (Csikszentmihalyi, 1990, p. 17).

This experience of working at full capacity in which one's challenges are met by skills to a point in which action becomes effortless is indicative of the "optimal experience" provided by flow. Nine component states have been characterized as existing in the flow experience as articulated by Csikszentmihalyi and colleagues' research. These nine component states are:

1. "Challenge-skill balance" (p. 598): if the challenge involved is too far beyond one's existing skills, frustration will likely result; conversely, if the challenge falls well short of one's skill set, boredom or even apathy will result. For the flow state to exist, an ideal balance between the level of challenge and the skills one possesses must be met.
2. "Merging of action and awareness" (p. 596): the actions that one is undertaking become so much the focus of one's attention, that awareness of what's occurring outside the activity is minimized.
3. "Clarity of goals" (p. 600): the sense of exactly what needs to be done is definitively clear.
4. "Unambiguous feedback" (p. 600): the activity itself directly informs one of advancement toward accomplishing clearly evident goals.
5. "Concentration on the task at hand" (p. 596): so much mental energy is expended toward the activity that interruptions or distractions are not as likely to have effect.
6. "Paradox of control" (p. 596): a sensation of being in control without having to try, yet when focus is shifted toward being in control, flow state is diminished.

7. "Loss of self-consciousness" (p. 596): Becoming "one" with the activity leads to diminished concentration on sense of self as separate from the activity.
8. "Transformation of time" (p. 596): less cognizance of the passing of time.
9. "Autotelic experience" (p. 597): Csikszentmihalyi's combination of the Greek words "auto" and "telos" translated "self" and "goal" relates to the idea that the activity in itself is so stimulating that the experience becomes inherently motivating (Fullagar and Kelloway, 2009).

Games in education vis-à-vis flow theory. Considering the scope of component states provided by the notion of being "in Flow," and considering the overwhelming scope of the evidence provided by decades of research in the field of positive psychology, particularly in the United States, it would seem to have been prudent for research on Flow theory to have been integrated into American educational strategy and practice. However, based on the evidence, integration of Flow theory into educational practice does not seem to have become widespread (Steinkuehler & Squire, 2012). Based on the study chartered by the nonprofit Bill and Melinda Gates Foundation, *The Silent Epidemic: Perspectives of High School Dropouts*, 47 percent of US high school dropouts note that a major reason for dropping out was that the students did not find their classes interesting. These young people reported being bored and disengaged…" (Bridgeland, DiJulio, & Morison, 2006, p. iii). Higher education is no less plagued by boredom as "59% of students find their lectures boring half of the time and 30% find most or all of their lectures to be boring" (Mann & Robinson, 2009, p. 243). What may provide a means to build a bridge across this divide in education is the use of learning games. Games, which can have a link to flow theory, may provide a critical link to overcoming boredom that has plagued educational practice for generations. McClarty and colleagues (2013) note:

> "Games contain the pieces necessary to engage students and help them enter a state of flow where they are fully immersed in their learning environment and energized and focused on the activity they are involved in. When complete attention is devoted to the game, a player may lose track of time and not notice other distractions." (p. 14)

Several key points with regard to games as related to education are illustrated by McClarty et al.'s *Gaming in Education* report and illustrate substantial overlap with the aforementioned attributes described by Flow theory. The key points that the report analyzes and provides supporting evidence for include the following. (Note: each of the phrases given in quotes are McClarty et al.'s original terms; descriptive analysis following, unless further delineated in quotations is the researcher's unique assessment.)

"Games are built on sound learning principles" (p. 8). According to constructivist educational theorists (further described later in this chapter), a key element to educational development is engaging in unstructured exploration. Taking the opportunity to think and understand things in an unregimented environment is not a distraction but can be an integral part of the learning process (Ke, 2009). As Piaget routinely asserted, the cycle of trying and failing and trying again, as evidenced in game play, is a very healthy part of the learning process. Likewise, the ability of a game simulation to prepare one for action gives root to higher levels of learning such as application, analysis and evaluation.

"Games provide personalized learning opportunities" (p. 9). One of the unique technical aspects of engaging in learning games via computer is that an infinite combination of decisions and records of experiences can be maintained. Each future experience can be presented by the game based on conditions included in all past decisions, experiences, successes and failures. Thus, this infinite ability to personalize a game experience becomes a tool whereby each person can be challenged to their unique combination of skills and experiences.

"Games provide more engagement for the learner" (p. 13). Games can vary in the degree or quantity to which a player provides input as well as the cognitive difficulty expected on any given action. As each person's skills, experience, and capacity for cognitive vigor are unique, the computer game has the ability to produce a unique combination of engagement level that matches the person's "flow state." This challenge-skill balance is one of the key attributes as described by flow theory.

"Games teach 21st century skills" (p. 16). There are multiple defined lists of "21st Century Skills" (McComas, 2014), and included in such lists are most commonly skills like innovation, collaboration, critical thinking, systems thinking, civic engagement, technical skills, and ability to produce with digital media. Each one of these skills is inherent in games of various sorts.

"Games provide an environment for authentic and relevant assessment" (p. 18). A game itself operates as an ongoing assessment in that advancing to higher levels in a game most always requires one to master previously encountered knowledge or rely on previously learned experience (Gee, 2010). As a game's background systems evaluate the player's every move or decision, immediate feedback is given. This, in fact, is one of the direct connections that games have with flow theory.

Constructivism and experiential learning: overarching paradigm for VR in education. "Tell me and I forget. Teach me and I remember. Involve me and I learn." (Franklin, n.d.). In concert with the previously described theories and concepts of Bloom's taxonomy, situated cognition, critical thinking, flow theory, and games in education, the broad school of thought known as Constructivism and the associated ideas of Experiential Learning provide an overarching paradigm within which application of VR and AR technologies may explicably find relevance in higher education. The idea of experiential learning has existed for centuries: Aristotle even wrote of learning by doing as early as 350 BC. The modern version of experiential learning theory was influenced heavily by the works of John Dewey in writings such as *Experience and Education* (1938). Dewey described experience as “a transaction taking place between an individual and what, at the time, constitutes his environment” (Dewey, 1938, p. 41). Dewey advocated for the educational process to promote understanding of the world beyond the classroom and encouraged the idea of organizing learning experiences as the means for learners to assimilate new ideas.

Following a similar scholarly tradition as Dewey (with an emphasis on experience), Swiss psychologist, Jean Piaget is credited as the founder of the school of thought known as Constructivism which proposes that learners construct knowledge as a product of interaction between ideas and experiences (Merriam & Bierema, 2014). The works of Russian psychologist, Lev Vygotsky, were likewise considered core to Constructivism: notably, the theory of “zone of proximal development,” (ZPD) and the concept of learning being “a social process mediated through a culture’s symbols and language” (Merriam & Bierema, p. 36). By ZPD, Vygotsky suggested that what a learner already knows is the beginning point for constructing new knowledge. A key role for a teacher in the learning process is helping learners discover their ZPD and helping them in the quest to higher levels of knowledge. Vygotsky is also credited with originating the idea of social constructivism which maintains that learning is foremost a social endeavor and that we construct knowledge primarily through experiences with others in society.

Another pioneer of cognitive psychology, American Jerome Bruner, further built upon the idea of ZBD with the theory of "instructional scaffolding" which explains that learning is "constructed" by providing the right support through experiences that build upon a learner's current level of understanding (Bruner, 1982). A set of tools for enabling instructional scaffolding that Bruner acknowledged as value-added a long as 60 years ago is the use of technology as a tool to assist the learning process:

> "…the past decade (sic) has witnessed the emergence of various *automatizing devices*, teaching machines, to aid in teaching. … The art of programming a machine is, of course, an extension of the art of teaching." (Bruner, 1960, p. 83)

From Bruner's references, we begin to see the relevance of using technology as an enabler in the learning environment – and the necessity for programming as a key input to that process. Put into context, Bruner made that visionary suggestion more than 20 years before the personal computer became a household item – and 55 years before the present study on VR in education. Passing away at 100 years of age during the time of this writing, Bruner was still an active teacher at NYU, and continued to advance the constructivist school of thought; he was a key idea influence to theorists David Kolb, Howard Gardner, and John Seely Brown.

David Kolb was a protégé of Jerome Bruner. In Kolb's seminal work on Experiential Leanring, he presented the theory known as Experiential Learning Theory (ELT) which builds a conceptual model around precepts that had been described by previous constructivist theorists. Kolb's framework for the Experiential Learning Cycle is given below (Kolb, 1984).

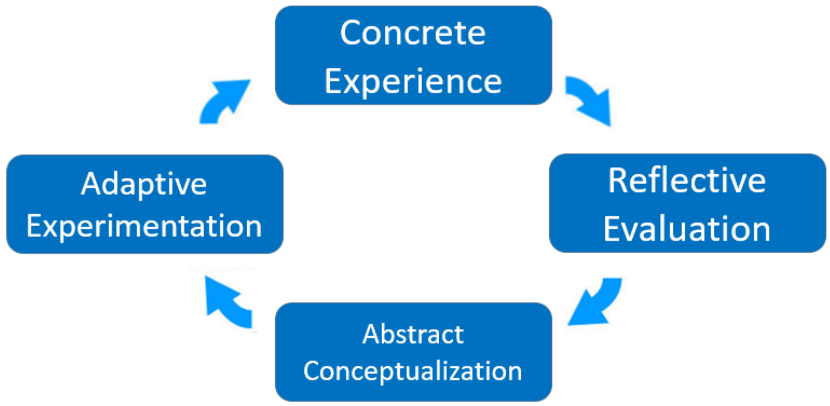

Figure 4. Kolb's Model of Experiential Learning Theory (ELT)

Kolb advises that, ideally, this cycle is repeated through the learning process. A planned concrete experience is accomplished; then, immediately afterward, the learners reflectively evaluate what has taken place by discussing what went well and what could have been done better with the experience. This all occurs ideally under tutelage of a knowledgeable facilitator. Upon completing the reflective evaluation, the learners then relate this evaluation to a broader conceptual model of the process or idea being studied. This abstract conceptualization gives rise for the opportunity to build scaffolding to higher levels of understanding. Then, the learners engage in adaptive experimentation in which the process in consideration is refined; new aspects of the process are introduced. Finally, the ELT model begins again with the learners engaging in a new, more advanced, or fundamentally unique concrete learning experience. Incidentally, many educational programs (including the Squadron Officer College), use the Experiential Learning Cycle as a model for experience-based learning events.

Another key protégé of Jerome Bruner was Howard Gardner, the developer of the Theory of Multiple Intelligences. This theory explains how human intelligence is manifest in many different forms. Gardner's original 1983 version of the multiple intelligences theory included seven types of intelligence; however, over the following two decades, Gardner expanded the theory to include two additional intelligences (Gardner, 2006). A summary of each of the intelligences follows:

- Visual-spacial: ability to mentally visualize graphical dimensions in space.
- Logical-mathematical: being adept at calculations and empirical reasoning.
- Bodily-kinesthetic: dexterity of the human body in form, speed and motion.
- Verbal-linguistic: aptitude to command language with precision.
- Interpersonal: natural skill in connecting with and understanding others.
- Intrapersonal: ability to identify and master one's own natural strengths
- Musical-rhythmic and harmonic: a natural "ear" for sound and song.
    - Naturalistic (added in 1995): gifted in connecting with nature
    - Existential (added in 1999): spiritual in temperament

This theory contends that intelligence is not a one-dimensional phenomenon, but rather, intelligence is multi-faceted and every person varies in each of the nine dimensions. Certain types of intelligence have traditionally not been emphasized as strongly as the focus of mainstream educational programs. Likewise, at any given point in history, educational practice has naturally been constrained by the level of technology at that time. These points have important implications to today and tomorrow's educational practice: principally, as traditional educational methods are bounded by technologies that existed in the past, and as certain types of intelligence were not focused on as predominantly in the past, perhaps the arrival of new technologies will usher-in a new era that enables these somewhat under-nurtured intelligence types to be promulgated like never before in history. (Campbell & Campbell, 1999; Campbell, Campbell, & Dickinson, 2004)

Immersive technologies: new possibilities interpreted through enduring Educational and social science theories. Each theory reviewed in this section provides context to illustrate how the data collected in the study are situated in the greater body of extant literature. As is the case with all qualitative research, the intent is to gain a better understanding of the process: here, the process is that of integrating Immersive Technology into the higher education learning environment. The research questions relate to challenges, opportunities, and practical applications of Immersive Technology in the SOC learning environment. As noted in chapter one, the study collected qualitative data from SOC Stakeholders via open-ended written questionnaires and semi-structured interviews to answer the research questions. Once the qualitative data were gathered, analyzed and interpreted, the study situated the interpretation into context of the extant literature reviewed here. The social sciences theories reviewed thus far are those which have key relevance in light of the data as collected and analyzed according to chapter 3 and reported in chapter 4. The next part of this literature review examines the nature of Immersive Technology which is the central theme addressed in this study.

The Nature of Immersive Technology

Immersive technology is a fairly new phenomenon (essentially less than 30 years), and, as such, understanding of it is still growing. In regard to definitions related to immersive technologies, a couple of key fundamental questions are "what is it?" and "what are the differentiations among the variety of terms used when describing immersive technologies?" In technology, the physical size and shape of a piece of computer hardware is commonly referred to as a Form Factor (Oxford dictionary). A type of form factor that is of key focus in studying VR and AR is the Head-Mounted Device (HMD). An HMD is a light-weight device that is worn like ski goggles on the user's head to deliver the user's eyes with a computer-generated field of vision. Also containing motion-tracking sensors that detect the precise location of the user's head in space, the goggles (worn simultaneously with lightweight headphones) can provide the user the vivid illusion of being "present" in places other than the user's current "real world" location. During the period the present research was conducted, the Oculus Rift Development Kit 2 (DK2) was the most capable consumer-oriented Virtual Reality HMD and was being fielded among software developers. The DK2 also was the device that SOC chose to use in equipping the Virtual Innovations Learning Lab as it was the only device available on the consumer market at the time the research began.

A form factor of the HMD that was released during the period of the present study which was different from the Oculus Rift DK2 was the Samsung Gear VR. An "innovator edition" of the Gear VR was made publicly available in late 2014, and the first consumer version was released in 2016. The Gear VR (a product made collaboratively between Samsung and Oculus VR) consists of a smartphone accessory shell in which the user of a specified smartphone inserts the device to serve as the illumination panel and processor to drive the VR experience. This form factor produces a wireless version of a VR HMD; however, given the existing level of performance of smartphone technology at the time of the present study, the Gear VR focused on smaller "mobile app" experiences. More intensive applications (speed and memory demanding) could be run on VR form factors driven by a higher-end PC platform. Examples of PC-based VR devices that became available during the research included the Oculus Rift "CV1," the HTC Vive, and Sony's PlayStation VR device that was based on the PlayStation 4 platform.

With augmented reality (AR), the user's present "real world" environment is to be part of the image perceived by the eyes; thus, the AR form factor enables the user's immediate surroundings to still be seen while virtual content is overlaid digitally. The Microsoft HoloLens, produced as a development kit as of 2017, is an example of an AR device; it resembles a set of eyeglasses with a pair of external shaded safety goggles shielding the glasses. Between the two lenses, 3-D images are projected and superimposed visually "onto" objects or spaces in the present reality. (Needleman, 2015; Metz, 2015).

How does virtual reality work? A pioneer in the field of VR and human-technology interface is Dr. Thomas Furness, founder of the University of Washington Psychology Department's Human Interface Technology Laboratory (HITLab) which began in 1989. Furness' research in virtual reality at the HITLab spans many disciplines. Prior to establishing HITLab, Furness was also founder of the U.S. Air Force's "Super Cockpit Program," in 1986 which was the first VR system to use virtual interface concepts extensively for training. One of Furness' studies in 2002 uses VR as a means of treating spider phobia; his report on this topic illustrates how virtual reality works:

> "Immersive VR works as follows. The subject dons a 'VR Helmet' that positions two goggle-sized TV screens close to the user's eyes. Each eye gets a slightly different image of the virtual world" (Furness et al., 2002, pg. 984).

The tangible element of VR as it is commonly used is the actual device: typically, an HMD or helmet that projects an image to each of the user's eyes.

> "The image shown to the left eye is offset slightly from that seen by the right eye. The brain fuses these two images into a single 3D image, helping to give users the illusion that the virtual environment has depth" (Furness et al., 2002, pg. 984).

Here, Dr. Furness describes how VR creates the illusion of "stereoscopic vision" – in which the brain takes two ocular nerve inputs (one from the left eye and one from the right eye), and fuses them together into one. This is what gives the mind the perception of depth in the field of vision.

> “Position tracking devices keep the computer informed of changes in the user’s head and hand locations. The scenery in VR changes as the user moves his/her head orientation (e.g. virtual objects in front of the user in VR get closer as the user, wearing his/her VR helmet, leans forward in the real world)” (Furness et al., 2002, pg. 984).

With normal vision in the “real” world, the brain compensates for continuous head and body motion as the ocular nerve images are being fused together. In order for the brain to be convinced that the two artificially-created fused images being seen are really coming from the outside world, the projection system also compensates for head and body motion.

> “Any one of these techniques alone might be unconvincing, but combined, they give users a uniquely compelling experience of ‘being there’ in the virtual world. The essence of immersive VR is the illusion it gives users that they are inside the computer-generated environment, as if they are ‘there’ in the virtual world” (Furness et al., 2002, pg. 985).

The concept of positional tracking as used in VR involves sensors on the user’s HMD which indicate the exact position and angle of the head to the precision of sub-millimeter accuracy. The same sensors can be used on the hands or other body parts to give the computer the ability to track and monitor the position of hands or body parts with the same degree of precision. This precise location is quickly processed by the computer and presented back to the eyes of the user giving the illusion that the hands or body parts, along with the head, are moving at the user’s command within the computer-generated environment. The ability to track the body in real-time and feed this data back into the user’s head-mounted device is what allows the eyes to see the user moving in relation to the virtual environment and results in the sense of what is frequently described as "being there," or presence, which is also defined as "the subjective experience of being in one place or environment, even when one is physically situated in another." (Witmer & Singer, 1998).

A technical aspect of positional tracking which must be considered in the incorporation of sensors in an HMD is the concept of Six Degrees of Freedom. Slater (2014) explains that to recognize an ideal Immersive Virtual Reality experience from an HMD, in addition to the high-resolution image being sent to each of the user's eyes independently, real-time tracking with six degrees of freedom for the head must also be integrated (elevated heave up and down; swaying left and right; swiveling forward & back; yawing "NO shake" left to right; pitching "YES nod" forward and back; and rolling side to side). The adjacent graphic illustrates each of the corresponding six degrees of freedom.

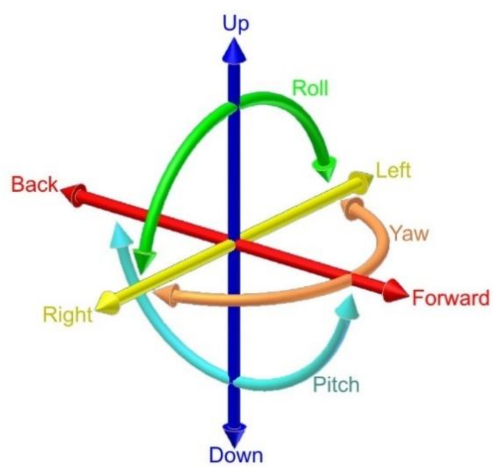

*Figure 5***.** Six degrees of freedom; Public Domain Image; originator: Horia Ionescu, 2010.

Enabling six degrees of freedom is a core component to making VR content more realistic because this is how the human head naturally operates and perceives the real world. One of the most commonly found principles to VR is that for VR to be "believable" to the mind, realism provided by the virtual experience must be as close as possible to how the senses would perceive the same experience in "real life" (Templeman, Page, & Denbrook, 2015; Simpson, Cowgill, Gilkey, & Weisenberger, 2015).

In addition to head tracking with 6 degrees of freedom, from the visual perspective, the VR experience also requires a real-time computer-generated virtual environment that continuously updates at a very high frame rate of about 60 frames per second (FPS) or more as the images are projected into the HMD (Slater, 2014). The "CG world" presented in the virtual environment becomes the new setting into which the VR user is "transported" upon donning the VR device. At a frame rate of 30 FPS or lower, the viewer will experience the phenomenon of judder which is similar to the choppy sensation that one perceives when watching early silent movies. The inverse of frame rate is known as latency which means how much lag occurs between frames: low latency, or high frame rate, produces a visually smoother experience, but of course comes with the cost of increased computing power required. A feature that is sometimes used in the effort to economize on computing power is the concept of intentional motion blur. When a digital photo is taken of a moving object using a slow shutter speed, motion blur results. In VR, by intentionally adding motion blur to the frames of a slower VR stream (24 FPS, for example), the effects of judder can be decreased or eliminated; however, the motion-blurred images will appear as clear and precise as non-blurred images at a higher frame rate (Babcock, Palmisano, & May, 2015; McMahan, Kopper, & Bowman, 2015; Polys, 2015).

Another visual attribute of VR that has been studied for use in future consumer VR systems is foveated rendering. The fovea is in the back of the human eye where the concentration of rods and cones is greatest and is the main convergence point of light coming from whatever the eyes are focused on. The process of foveated rendering in VR takes into consideration the fact that the sense of vision is at greatest resolution within the central focus area (commonly referred to as the fovea as well in this process.) Outside the fovea, or that which is not the eyes' main focus, resolution is not required to be as robust since the mind only needs highly-focused vision within the fovea. Foveated rendering requires hardware sensors that track the exact fixation point of each pupil and relay that information to the computer's processor in order to allow the processor to render the fovea area in high resolution and everything else in lower resolution. Effectively, this allows the system's processors to do less computation to produce the effect of having the user see high resolution everywhere he/she looks. Using less processor resources frees-up the capability for other things: like gesture recognition and haptics (Wang & Winslow, 2015; Badcock, Palmisano, & May, 2015).

Reiterating a theme previously noted, the more like the "real world" that the virtual environment is made, the more the mind can be convinced that the virtual world is "believable." In the real world, humans interact with the world manually. Practically every person who experiences VR for the first time instinctively looks down right away to see if they can see their hands. The ability to recognize the motion of the user's hands is known as gesture recognition. With the correct arrangement of sensors, new consumer VR systems are being fielded that are capable of gesture recognition which leads to the ability to perform motion capture or MoCap. Using a suitably outfitted MoCap system, the VR world can be made to include the user's bodily movements in the virtual world and to associate these movements with the user's personal digital representation in the VR world (a.k.a. "avatar"). The end result is a concept that creates the opportunity for embodiment: an incredibly powerful phenomenon of being inside the virtual world. (Dinar, Tekalp, & Basdogan, 2015; Lawson & Riecke, 2015)

Once inside the virtual world, the VR system process of providing haptic feedback involves allowing the user to feel tactilely the sense of surfaces, textures, weights, shapes, motions, accelerations and other related senses. Going beyond visual and audio systems, providing motion capture and haptic feedback are the next domains for VR to create a greater sense of realism in making "first person" VR to become even more compelling (Turk, 2015; Pompescu, Trefftz, & Burdea, 2015).

The Science and Art of Human Sensory Perception

Immanuel Kant**,** in the 18^{th} century, described a key foundation of epistemology (how we "know") as being based first on perception as obtained through the natural sensory systems: the phenomenal world conveyed via the senses. "All our knowledge begins with the senses, proceeds then to the understanding, and ends with reason. There is nothing higher than reason." (Kant, n.d.). This idea of the senses being the starting point of developing human understanding which further leads to reason has remained for centuries as a key construct within modern philosophy. Preceding Kant, was the fundamental philosophical school of thought known as Empiricism which relies even more extensively on the notion of sensory experience as the primary source of knowledge. Evidence is gathered through observation in experiments using research methods including the scientific method and interpreted through the senses as the basis for developing theory.

The five main senses. Given the essential role played by sensory perception in human knowledge and given that the intended purpose of Immersive Technologies is that of altering the inputs to human perception to present the illusion of a separate (virtual) or augmented version of reality, an understanding of human sensory perception is relevant to the subject of Immersive Technology in Higher Education. In the 4^{th} century BC, Aristotle recognized five human senses: seeing, hearing, touching, smelling, tasting. The five primary senses as described by Aristotle using their scientific names in English are as follows:

- Seeing (ophthalmoception)
- Hearing (audioception)
- Touching (tactioception)
- Smelling (olfacoception)
- Tasting (gustaoception)

(Pediaopolis, 2014).

A sense is defined as: "A system that consists of a group of sensory cell types that responds to a specific physical phenomenon, and that corresponds to a particular group of regions within the brain where the signals are received and interpreted" (Pediaopolis, 2014, p. 2).

Given this definition, the list above is not really all-inclusive. It was monumental in Aristotle's time to speak of delineating the sensory systems and the usefulness of each sense to developing intellect. Given, however, that human "sensory cell types" were not discovered until more than 1,300 years after Aristotle, and further, magnetic resonance imaging (MRI) for cognition and brain science was not a usable tool until the mid-1990's, it is easy to appreciate now that there are more than 5 human senses. This gives rise to a notion of human perception being more complex than commonly realized (Nagel, 1974).

Human perception beyond the five main senses. When taking consideration of the essence of this definition of a "sense," (sensory cells, response to phenomenon, group of regions in the brain) there are many more senses that must be acknowledged. Even within what is thought of as the perception of sight, while ophthalmoception includes perceiving the phenomena of brightness and color by using rods and cones, there exists a further demarcation:

- Stereopsis – sense of depth perception; often referenced as a post-sensory process whereby the visual cortex integrates patterns of objects into the visual memory. Here, we see a different part of the brain in use than with brightness and color alone (Badcock & Palmisano, 2015).

Going further, multiple sources on sensory perception reference the following ten senses in addition to the above six:

- Proprioception: (sensing the position in space of one's own limbs or body parts)
- Proprioceptive sensors are found within muscles and billions of microscopic sites throughout skin; also from within connective tissue, sensation is conducted through the central nervous system.
- Kinesthesia: (sense of motion of limbs and coordination of muscles when walking, or manually manipulating the environment; relies upon multiple sensory inputs including optical nerves and proprioceptive sensors)
- Equilibrioception: (Balance & acceleration; occurs from within the vestibular system of the inner ear)
- Vection: (sense of self-motion in terms of the full body mass in a given direction)
- Spatial orientation (not just a visual sensation; a mental awareness of "point in space")
- Nociception (sensing pain)
- Thermoception (sensing temperature)
- Mechanoreception (sensing pressure)
- Chronoception (sense of the passing of time; another post-sensory cognitive function)
- Synesthesia: sensory perception in which stimulation of one type of sensory input evokes in the person's mind a sensation more commonly associated with another type of sensory input (numbers invoking a sense of a color or shapes invoking a smell.) This is a rare

form of perception (Lawson & Riecke, 2015; Dindar, Tekalp, & Basdogan, 2015; Jones, Dechmerowski, Oden, et al., 2015).

From a cognition standpoint, consider all of the many regions of the brain that are receiving and interpreting signals from billions of different nerve sensors of many different types. Yet, still today, most people think of there being only 5 senses. The reductionist notion that objective observations are limited to 5 senses provides a less unified understanding of the world. Moreover, in the milieu of the vast majority of educational settings, even in modern times, the majority of planned learning activities limit engagement to two human senses: ophthalmoception (sight) and audioception (hearing). One of the intrinsic values to using VR and AR is that these technologies enable the learner to utilize a wider assortment of senses as explained in the following sections.

In an Immersive Technology system, a factor that is of prime importance from the sensory perception standpoint is the concept of fidelity which is defined as "the degree to which an electronic device (as a record player, radio, or television) accurately reproduces its effect (as sound or picture)" (Merriam-Webster, 2015). Fidelity, particularly within VR takes-on an even more specific meaning with relation to the senses. There are several degrees of fidelity as described from the human factors side.

- Involvement: Interested but not deeply involved, like watching a TV program while eating.
- Immersion: Deeply absorbed into the content of a lesson or program essentially as a spectator, like enthusiastically watching a sporting event.
- Presence: Mental image of actually being there in-person. (Like being engrossed in a novel.)

- Embodiment: "in the body of…" – the inner mind opens-up to the illusion and produces the feeling as if the perception is being made from the senses of the figure involved such as another person, animal, character, machine or avatar – (No analogy to provide here without VR) (Chertoff & Schatz, 2015).

From this simplistic human factors perspective, the further along this scale of deeper experience the user is able to recognize, the higher "fidelity" the application or device is acknowledged to provide. A complicating factor to measuring fidelity in this manner is that the assessment of which level is felt is determined subjectively by the individual user, and each user's experience may be different from others.

The concept of fidelity in a VR system from the sensory perception side is measured by how well the system convinces the user's sensory systems that the inputs are coming from the virtual world versus the real world. The higher fidelity of the VR, the more likely the system (hardware, software, storyline, etc.) is designed to take advantage of known elements of the VR platform in using sensory-induced phenomena (McMahan, Kopper, & Bowman, 2015). Several sensory-induced phenomena are known to be involved in an immersive VR experience:

- Stereopsis: Depth perception induced by stereoscopic projection (images sent to each eye in a format that reproduces the overlapping field of vision as well as monoscopic peripheral vision)
- Visually-induced sense of Spatial Orientation and Vection (self-motion)
- Directed sound: "…the virtual placement of sound anywhere in a 3D space with pinpoint accuracy, creating the perception of real source direction, distance, depth, and movement relative to a listener when heard through standard stereo headphones" (VisiSonics, 2014). OculusVR has licensed RealSpace™ 3D Audio by VisiSonics Corporation (Hollister,

2015) which is a 3D audio engine that is the first-ever sound system to produce true directed sound with accuracy as exact as the human ear can discern.

- Chronoception, proprioception, kinesthesia, equilibrioception: each of these senses must be replicated as closely as possible to the user's expectation in the virtual world: particularly with reference to what the eyes are seeing (Templeman, Page, & Denbrook, 2015).
- Immersion: the VR system replicates as many of the above sensory inputs as possible to send orchestrated inputs to the mind so as to be fused together instantaneously. When sensory inputs are not in harmony with each other, a decrease in the sense of immersion results. Mis-match between certain sensory inputs can result in simulator sickness (Turk, 2015).
- Embodiment: visual inputs from the HMD must synch as closely as possible to one's real-world proprioception, kinesthesia, and equilibrioception inputs – i.e. placement and motion of one's "real" limbs corresponds exactly with their expected placement in the virtual world (Lawson & Riecke, 2015).
- Haptic Feedback: haptic devices are in development that may enable the use of certain forms of touch-oriented senses (tactioception, mechanoreception, thermoception, nociception) (Dinar, Tekalp, & Basdogan, 2015).
- Olfacoception: The sensory system with one of the most powerful impacts to cognitive states of memory, attention, emotion and engagement is the olfactory system. Scientists and developers are working to integrate the sense of smell into virtual learning. For training in environments in which chemicals or malodors are inherent aspects to the real setting, having the fidelity of stimulating the olfactory in accordance with the original

setting can enable the VR learning experience to be more germane and better prepare the learner for what he/she would encounter in the real world (Jones, Dechmerowski, Oden, Lugo, Wang-Costello, & Pike, 2015).

- Of significance: before now, in a traditional classroom or even in distance learning scenarios, it has been relatively rare to purposefully design learning activities that use sensory-induced phenomena as agents to generate unique learning experiences. VR enables a learner to engage a wider variety of human senses and types of intelligence. When curriculum designers and teachers make use of this wider variety of sensory inputs, deeper learning can occur.

Previous Research on Application of VR

Research on VR in general (benefits, outcomes, effectiveness). As previously explained, the primary aim of higher education is to develop graduates who are critical thinkers. From a pedagogical standpoint, this means focusing on higher-order levels of learning. Siddique, et al. (2013), referred to Bloom's revised taxonomy in noting that rather than Remembering, Understanding, and Applying, when designing educational activities at the higher levels, we must focus on Analyzing, Evaluating, and Creating. To move to these higher levels of learning or critical thinking, the educational activities must go beyond lecture and standard teaching methods and, instead, concentrate on activities that require students to innovate and create. Siddique et al. (2013) describe an experiential learning interactive game designed for mechanical engineers that guides students through the process of analyzing, constructing, and manufacturing a crankshaft with diverse variables of cost and physical attributes. The end result of the student's VR artifact becomes a component to a racecar that the student actually races in VR on a racetrack. The student's success in making the engineering decisions related to manufacturing tolerances becomes a factor on how well the virtual racecar competes in the race.

In comparing test and survey results of the students who participated in the interactive VR activity to a control group of students who only participated in lecture and other traditional educational methods, Siddique et al. demonstrated empirically that the students participating in the interactive VR activity scored higher on the test of higher-order thinking and likewise enjoyed the learning activity more. Implications for practice to the graduate PME environment involve the strategy of planning learning events that require students to create VR artifacts with knowledge they have learned and apply those artifacts in some type of competitive manner.

According to Chau, et al. (2013), another key opportunity for 3D virtual learning is in the area of enabling cultural exchanges. Since students from anywhere in the world can meet in the virtual space, taking the opportunity to connect students socially through interaction between their avatars can provide the opportunity for a more global perspective on problem-solving.

The University of Toledo Interprofessional Immersive Simulation Center (UT-IISC) is a 65,000 sq. ft. simulation facility that enables health care providers to operate in an innovative, forward-thinking environment to create new processes for improving human performance. Within this sophisticated modeling and simulation establishment, Immersive VR and holographic technology are used to produce unique learning experiences for a wide range of healthcare professions. One of the unique applications is an Elliptical Virtual Hospital that includes an Intensive Care Unit, Labor and Delivery Unit, Pediatric Unit, and Trauma Suite – all surrounding a virtual central control tower (Boyers & Zolenock in National Research Council, 2015).

Fowler (2014) provides a sound model that guides action research toward focusing directly on learning outcomes. By considering both the representational fidelity (i.e. technical aspects) of the equipment as well as the learner interaction within the virtual environment, Fowler notes that the design for learning should result in achieving learning outcomes. Fowler's technical/behavioral approach to modeling experiential learning in 3D Virtual Learning environments provide an important standard to use when describing how the pedagogy corresponds to the experiential learning outcomes.

VR communities of practice: VR pioneers & benchmark VR R&D labs. Frequently credited with popularizing the term, "Virtual Reality," interdisciplinary scientist, Jaron Lanier, has been researching VR since the mid-1980's. Since 2006, Lanier has worked with Microsoft and, since 2009, with Microsoft Research Labs. Lanier has produced seminal works on such concepts as "somatic cognition" (thought that manifests in one's physical body before being registered in the mind), "homuncular flexibility" (ability of a person to control a virtual body that is different from the usual human shape), and "avatar-directed cognition" (the ability to use a distorted virtual self to effect learning) (Lanier, 1999; Lanier, J., 2010). Further concepts researched by Lanier include "haptics" (using touch in computer simulations), time distortion, simulator sickness, and using VR for physical therapy (Lanier, 2007).

The Stanford University Virtual-Human Interaction Lab (VHIL), under the leadership of Dr. Jeremy Bailenson, has produced a prolific database of studies on the psychological aspects of operating in virtual environments. A few examples of studies from VHIL include:

- "Many ways to walk a mile in another's moccasins: Type of social perspective taking and its effect on negotiation outcomes" (Gehlbach, Marietta, King, Karutz, Bailenson, & Dede, 2015)
- "The Relationship between Virtual Self Similarity and Social Anxiety" (Aymerich-Franch, Kizilcec, & Bailenson, 2014)

- “Does the Mask Govern the Mind?: Effects of Arbitrary Gender Representation on Quantitative Task Performance in Avatar-Represented Virtual Groups” (Lee, Nass, & Bailenson, 2014)

Another leading community of practice for virtual reality research is the University of Washington Human Interface Technology Lab (HITL), led by Dr. Thomas Furness, III. Studies produced by HTIL relate to how the human-technology interface can effect tangible outcomes. Dr. Furness, who previously worked for the Air Force, pioneered the Air Force Super Cockpit program in the 1980’s. Examples of the studies produced by HTIL include:

- “Virtual reality as an adjunctive pain control during burn wound care in adolescent patients.” (Hoffman, Doctor, Patterson, Carrougher, & Furness, 2000).
- “The Effectiveness of Virtual Reality for Dental Pain Control: A Case Study.” (Hoffman, Garcia-Palacios, Patterson, Jensen, Furness, & Ammons, 2001).
- “Virtual reality in the treatment of spider phobia: a controlled study” (Furness, Garcia-Palacios, Hoffman, Carlin, & Botella, 2002).

VIRTSIM and Dauntless by Motion Reality, Inc.. Auburn University mechanical engineering professor, Dr. Nels Madsen, is an Academy Award-winning pioneer of motion capture from his work with the movie Lord of the Rings. Madsen is also developer of the innovative VR systems known as VIRTSIM and Dauntless. These high-end virtual reality systems are used for training law enforcement agencies across the U.S. as well as by the FBI, the US Armed Forces, and the U.S. Marshal’s office. VIRTSIM began in 2009 and was the original platform provided by the Marietta, Georgia, firm, Motion Reality, Inc. In 2015, the firm launched the successor platform: “Dauntless.” Both systems provide the capability to train participants in three-dimensional virtual reality via head-mounted devices, motion capture, and haptic feedback systems. The systems enable officers to practice any type of scenario they may be expected to face in real-world emergency situations. As the learners simulate these real mission experiences in a facility about the size of a basketball court, they become more prepared for the wide variety of possibilities. A key advantage that learning in VR enables is that the life-threatening degree of danger inherent to constructed live training scenarios is minimized.

While engaged in VIRTSIM or Dauntless, the performance of each user is tracked electronically by cameras from multiple angles, providing rich opportunities for the "reflective evaluation" stage of the ELT model. In the final report on the training experience, the learner can analyze movements in relation to friendly or criminal agents and compare the entire group's performance to the ideal model in the "abstract conceptualization" stage of the ELT model. Developing more advanced tactics that go beyond previous models can occur in the "adaptive experimentation" of the Dauntless exercise as the learners engage for another experience.

> "'This is a huge help for officers when they are rehearsing a mission,' said Joe Harmon, a retired FBI tactical trainer and Motion Reality employee. 'If the department can get the floor plan of a house, we can build a model of the house to the exact specifications using our technology. That is valuable to an assault team because you are not going into the unknown'" (Conrad, 2012, p. 1).

The software technology used to provide the high-end gaming capabilities and take advantage of the cutting-edge graphics in Dauntless is known as CryEngine, which has also been commonly used by dozens of popular games since 2006. This consideration gives rise to the conclusion that the traditionally expensive VR applications are beginning to converge – both in hardware and in software – with less-expensive consumer applications (Barrie, 2015, Riese, 2016).

The Dismounted Soldier Training System (DSTS) by Intelligent Decision. Another high-end VR system used for military-style tactics training that uses the CryEngine gaming platform is known as DSTS and is used in multiple soldier training centers worldwide by the U.S. Army. DSTS is also capable of creating any type of terrain to present the learner with a high-resolution 360-degree virtual operating environment. While the virtual training world does not replace live training, there are many training objectives that can be accomplished virtually, so that when the limited amount of live range time becomes available, units can focus more precisely on needs that absolutely must be done live. "'It's hard to imagine a mountainous terrain in Indiana, but the DSTS can create it,' said Sgt. 1st Class Aaron Hammond, Operations, 157th Infantry Brigade, First Army Division East. 'The DSTS allows a soldier to wear the simulation instead of sitting inside of a simulator,' said Matthew Roell, DSTS operator" (Zamora, 2013, p. 1).

DSTS places a key spotlight on the concept of fidelity. From expressions of emotion on virtual faces to specific details of combat weapons to the exact topography to match the virtual location, all aspects thinkable are made to be as close as possible to the original. Using a Head-Mounted Display, tracking sensors, and haptic devices, DSTS enables soldiers to work as a team and improve group leadership and team communication skills (Montalbano, 2011).

Given the fact that newly emerging hardware and software for VR are arriving in the commercial VR sector, the possibility of enabling the same level of fidelity on a system that is inexpensive is much closer than most people think.

"Virtual reality used to be the purview of government funded bodies and the military. Now of course, VR is heading towards a civilian market, albeit with very different R&D

goals. At this rate, the military will be opting to piece their training systems together from the shelves of Best Buy" (James, 2015, p. 1).

Team Orlando – Joint Services Lead for Modeling & Simulation. Virtual Reality, Augmented Reality and Immersive Technology fall under the broader umbrella of what the U.S. Department of Defense (DoD) commonly refers to as "Modeling and Simulation." Colloquially known as "modeling & sim," the DoD organization that is charged with the mandate to orchestrate common standards among the armed forces with regard to compatibility and interoperability of modeling & sim systems is known as "Team Orlando," whose central component unit is the Joint Training Integration and Evaluation Center (JTIEC). All the military service components have separate resourcing, research & development channels, and most importantly different mission sets to train for. Given the challenge of keeping the services interoperable with these valuable resources, Team Orlando has representation from the Army, Navy, Marine Corps, Air Force, the Coast Guard, and the Joint Forces Command.

Aircraft simulators are categorized as a part of modeling & sim, and given that every aviator from any branch of service (as well as non-military) has a critical amount of simulator training mandated by the FAA (as well as additional training mandated by their services), it is easy to see how modeling and sim is a multi-billion-dollar industry. Of course, the use of consumer VR in this industry is but one small (though growing) piece of what Team Orlando coordinates. While the strategic focus of modeling and sim are still on simulators for aircraft, ships, tanks, and other large combat assets, within the consumer VR realm, there are many lessons that can be learned from those technologies (Orlando, 2015).

Air Force Agency for Modeling and Simulation (AFAMS). One of the participating components to Team Orlando is AFAMS, who along with each of the armed services' equivalent agencies, operates in Orlando, America's largest cluster of expertise in the modeling & sim industry. In AFAMS' role as the U.S. Air Force's lead agent for modeling & sim, the organization carries the responsibility for centralized management of the Air Force's part of Live, Virtual, & Constructive (LVC) joint operational training. In a generation where the most advanced weapons platforms are incredibly expensive, it becomes a resource challenge to obtain the level of training needed for each and every weapon system operator. The role of LVC is to ensure the maximum return on the limited amount of training resources. Using the Air Force example, representing the "live" portion of LVC, is the live pilot flying a real, live aircraft over real-world terrain. The "virtual" portion of LVC involves a live pilot who's "flying" (operating) a fixed aircraft simulator, and due to the data pipeline being merged centrally, all of both pilots' data systems provide them perceptual indications that they are flying "together" – i.e. both of them are flying over the terrain where the live pilot really is actually flying. Then, the "constructive" aspect of LVC includes several "only digital" aircraft (both friendly and adversary) appearing on both pilots' displays as flying in the same airspace. This somewhat simplistic analogy illustrates how LVC can maximize training resources (only one aircraft actually launched from earth, yet a full complement of aircraft were engaged in the training scenario.) Thus, LVC greatly increases the safety factor only since only one aircraft was flying in the real-world airspace. The Air Force perspective is that LVC should be at the core of training programs including multiple simulated operational threats, systems and people (McKaughan, 2015).

VR for training pilots of 5th generation advanced fighter aircraft. The latest generation of fighter aircraft, known as "5th generation" – which includes the F-22 Raptor and the F-35 Lightening III, are so capable that no other aircraft is able to compete. Not even on the

Nevada Test & Training Range (NTTR) – the most advanced, most sophisticated, air combat training range on the planet – can capabilities of 5th generation aircraft be fully put to test (source: primary researcher; having served as an NTTR Mission Support Official). Moreover, 5th generation aircraft have capabilities that the Air Force, Navy, and Marine Corps would rather not put onto public display often – in order to keep would-be adversaries from studying them well and being prepared for how to counter them. Given the sophistication of these marvels of modern technology, the services have turned to using VR as a primary medium for training 5th generation aircraft pilots and support personnel (Pearson, 2016).

> "Today, virtual training systems are so advanced that more than 70 percent of F-35 pilot training is completed in a simulated environment before the pilot climbs into a cockpit. Compare that to F-16 training where pilots fly 40 percent of their qualification events in simulators" (Lockheed Martin, 2015, p. 1).

At the F-35 Academic Training Center at Eglin Air Force Base, Florida, F-35 pilots advance to high levels of competence in the virtual version of the aircraft before ever taking a flight in the live aircraft.

> "We are using game engines and the actual plane's software and controls to create a simulated environment that feels and looks real," said Mike Luntz, Lockheed Martin's F-35 Training System director. "Think about the F-35 simulator as a snow globe with the pilot in the middle. The pilot is completely immersed in a virtual world" (Lockheed Martin, 2015, p. 2).

Taking advantage of fully immersive virtual reality is a quest that the armed forces operational communities have been doing for decades– all the way up through the most sophisticated platforms as seen here with the F-35. Using the lessons learned from them, the next step can be applying the lessons learned within education and training environments where VR has not quite yet found its place.

VR for Post-Traumatic Stress Disorder (PTSD) treatment. PTSD is a psychological disorder that affects a patient mentally at a deep level. With the past 15+ years involving hundreds of thousands of U.S. military personnel deployed into combat environments, one of the resulting crises seen by psychologists today is the rise in incidence of PTSD among veterans. One of the tools being used by psychologists today is the use of immersive VR for what is known as Virtual Reality Exposure Therapy. This treatment enables the patient to re-create the scene that triggered the PTSD and helping the patient through processing his/her feelings about the events (Lewis, 2014; Hartano, et al., 2014).

> "It's an extremely effective treatment because it is a patient's personalized reality that they learn to process, control and regulate," Dr. Michael Valdovinos, chief of outpatient behavioral health at Landstuhl Regional Medical Center in Germany, said in an Army release. "Visual memory is powerful, and if I can use that to help patients create their own movie scene, then they can move into it to rewrite their own script" (Pomerleau, 2015, p. 1).

This new means of enabling patients to deal with unseen wounds from combat is yet another method in which the Virtual Reality as a tool has powerful effects in the affective domain of the human mind.

Air Force Performance Lab. Today's "under 30" or "millennial" generation was aptly labeled by Marc Prensky as "Digital Natives" (Prensky, 2001, p. 1). A characteristic of Digital Natives with which the Air Force Recruiting Services (AFRS) has connected is that Digital Natives enjoy using technology. A new tool used by AFRS is known as the "Air Force

Performance Lab." This innovative experience has been launched as a nationwide campaign to bring a virtual piece of the "real" Air Force to perspective Air Force recruits to let them examine if it's something they would like to do. In collaboration with several commercial partners, the AFRS envisioned this experiential lab that travels across the country and uses the Oculus Rift VR device to provide "in-world" virtual tours of multiple different career fields across the Air Force (Craftsman Industries, 2016). Aimed at students who have done well and enjoy Science, Technology, Engineering and Math (STEM) subjects, the Air Force Performance Lab piques the interest of exactly the right demographic – considering that most Air Force specialties have a technical component involved. From piloting a fighter jet aircraft to controlling the airspace as an Air Traffic Controller, the VR experience offered by the new AF Performance Lab had been a considerable success at connecting with Digital Natives. The Performance Lab also includes a gamified experience in which participants test their skill in controlling an aircraft in flight. The aircraft setup includes 360-degree immersion, omni-directional audio, hands-on flight controls and haptic feedback to make the experience realistic (Nafarrete, 2015).

Through the communities that invested in the high per-user cost of VR in the past, multiple applications of VR have existed and produced a wide assortment of discoveries and conclusions on how VR can best be used. As the technology commoditizes and becomes available on a more widespread basis among consumers, these lessons learned and theoretical underpinnings should be taken as prerequisite knowledge for programmers and practitioners. Through VR Communities of Practice led by pioneering VR research facilities, as well as successful early VR applications such as VIRTSIM, Dauntless, and DSTS a quantum level of understanding for new VR initiatives, if appropriately assimilated as common knowledge, can empower the next wave of using VR to improve humanity.

Positives/Negatives to Immersive Technologies Manifest in Non-Educational Domains

While Virtual Reality has a strong record of success in what has been known as the "dawning" years of the technology, like any new platform, there are inherent risks that should be considered by practitioners and evaluated by each individual before becoming directly involved in any VR or immersive technology activity. By understanding these risk factors and weighing them with perceived benefits to be obtained by using VR, a learner or user can make an informed decision on whether to engage in VR activities.

Risks shown to be manifest with immersive technology. Certain physical and mental aspects need to be considered when choosing to participate in a virtual reality simulation. While this section merely introduces the concepts, each of these points has volumes of research written and countless legal ramifications are applicable. As one will realize when opening the box of a new VR device, these risks are taken very seriously by VR device manufacturers and VR application developers:

- Physiological: potential for motion sickness, nausea, dizziness, headaches, vomiting (Hale & Stanney, 2015).
- Physical mishaps: Lack of awareness of "real world" surroundings (furniture, people, etc.); one system known as "lighthouse," a component of the HTC Vive system, attempts to overcome this risk by rendering outlines of "real world" objects and walls in the virtual environment to prevent tripping hazards (Lawson & Riecke, 2015; Chen et al., 2014).
- Certain physical disabilities & conditions impact participants' ability to achieve the full spectrum of immersion. Flashing lights from the display can trigger seizures in people with epilepsy. People with vision in only one eye or hearing in only one ear, just as outside of VR, are not capable of seeing in stereoscopic VR or hearing full omni-directional sound (Hale & Stanney, 2015).

Factors that challenge immersive technology use. Beyond physical and psychological risks directly to the users of VR applications, there are also certain factors that challenge the use of VR from a developmental and societal perspective. A few of the more commonly articulated factors that challenge the use of VR are as follows.

- Attitudinal: perspective that "high tech" means "low touch." This idea asserts that the decreasing amount of personal contact resulting from increased use of technology negatively impacts our humanity (Hale & Stanney, 2015).
- Technical expertise required to develop VR content: this factor refers to the notion that while VR currently is a nascent technology, the primary people who generate content in the VR ecosystem are those fluent in the programming languages of virtual environment development – chiefly 3D gaming engines such as "CryEngine," "Unity," "Unreal," and others. On the other side of this challenge is the optimism that the commercial market may inevitably demand better tools for users to become "makers" or "creators" of VR content. The beginning of such a "VR maker-movement" could begin with users who are not programming specialists being able to draw from an inventory, index, or encyclopedia of previously developed digital assets and utilize those assets in a user-friendly way. Similar to how PowerPoint turned users into Slideshow Creators and Facebook turned users into Social Media Content Creators, at some point, there will inevitably be a platform or application that enables anyone with a VR device to be a VR Content Creator (Scherba, 2016).
- Initial investment required to start VR program: this challenge refers to the funding required for equipment, labor hours to set-up and maintain, and investment in staff development time to utilize VR assets. While costs per user have decreased

exponentially in recent years, the investment remains a sound issue to be considered (Hertz, 2015).

- Lack of existence of a common “language” for use of VR: for years, anytime one referenced “VR,” they most likely were talking about a 2D virtual environment such as “Second Life,” which, since 2003, has been engaged by over a million users worldwide via flat-panel computer monitor. Yet, with the advent of consumer VR devices like the Oculus Rift, there is no consistent terminology for one to use to differentiate the two, very different, experiences of 2D flat-panel virtual worlds from immersive 3D VR. Likewise, confusion exists over terms like “immersion,” “presence,” and “embodiment.” To exacerbate this concern, even among those considered experts, the terms are not often used consistently (Schnipper, et al., 2015).
- Increased network bandwidth required to facilitate more robust data streams that are required by VR: while the present state of VR requires a substantial bandwidth to stream smoothly, by increasing the volume of VR use, bandwidths increase proportionately (Hale & Stanney, 2015).

Factors that facilitate immersive technology use. While there are risks and challenges to VR that serve to present barriers, likewise, there are a multitude of factors that serve to facilitate the use of VR. The present research serves to highlight both negative and positive factors with regard to use of VR, particularly in the field of higher education. Some of the factors that facilitate the use of VR that are frequently discussed in academic writing and popular technology media are as follows:

- Attitudinal: Millennials favor use of technology and games (Schnipper, et al., 2015).
- Technical requirements to operate are usually not difficult: the technology is designed to fit directly to the human way of interfacing with the world (Lee, Wong & Fung, 2010).
- Increasing speed/capacity of technology making capabilities that previously were physically impossible become light-weight, portable, even "wearable" devices (Hertz, 2015).
- Lowering cost of technology bringing capabilities that previously only were within price range of well-funded enterprises down to be affordable to everyday users (Riva, Mantovani, et al., 2007).

Chapter Two Summary

This chapter began by examining a series of time-honored educational and social science theories that serve to provide the theoretical grounding for the use of Immersive Technologies in education. Given the Constructivist paradigm and the Experiential Learning school of thought as the over-arching foundation, the author then analyzed the technical nature of Immersive Technology. Given these engineering-oriented aspects of VR and AR, the next item reviewed was the human biological senses that are involved in using these technologies and the unique ways that humans derive experience from well-designed immersive technology. In looking at applications of VR in previous fields, the author outlined several areas in which the use of VR in educational settings could be informed from past practice in industry and the military. Last, the author included a compendium of the positives and negatives of many of the ways that VR has been used.

In chapter three, the methods used in the present research are defined and discussed, followed by chapter four which presents the results from the data collection and analysis. Last, chapter five provides the conclusions made from the research study and presents implications for practice and suggestions for future research endeavors.

Chapter III: Methods

This qualitative intrinsic case study examined the process used by the Squadron Officer College (SOC) in the quest to integrate a completely new technology into the PME/higher education learning environment: Virtual Reality. Qualitative research is a methodological approach that seeks a deeper understanding of some aspect of a phenomenon, event or situation. The qualitative approach often begins (as does the present research) with a situation about which little is known and methodically conducts inquiry to better understand. In formal research methodology known as case study, purposive samples are examined in-depth with an aim to produce deeper understanding of the larger questions at issue in the case. The term, "intrinsic" means that the individual case itself (SOC's process of inquiry on VR) provides the ultimate value to understanding as opposed to other types of case study (instrumental: in which the case is more of an instrument to understanding an issue, or collective: in which multiple cases are looked at simultaneously) (Berg & Lune, 2012). Approached from a pragmatic tradition (i.e. having an outlook and expectation toward practical application of the knowledge gained), the study analyzed the collaborative inquiry process used by SOC – identified as the Commander's "VR in Education Challenge"– as a model to better understand the nature of VR technology as a learning tool and to discover potential future applications of VR technology in higher education. By using qualitative research methods to learn more from the personal inputs from individual Stakeholders involved in SOC's intrinsic case, the present research provides insight on the larger questions of challenges, opportunities, and potential applications for VR in education. In this chapter, the specific methods used in the conduct of the study (open-ended questionnaires and semi-structured interviews) are described in context with further background details on this pioneering initiative by SOC.

Purpose of the Study

The aim of this research was to inform the Air University policy process, curriculum development efforts, and instructional practices on strategies to enhance and support the integration of VR into the graduate PME learning environment. The study sought to identify the elements that would be potential challenges, means to overcome challenges, and opportunities for integrating Immersive Technology into the learning environment and to synthesize a compilation of potential VR applications with relevance to PME and grounding in time-honored educational and social science theories. These challenges, opportunities, and applications should provide important foundational information for other higher education institutions seeking to use VR as a learning tool. Further purposes of the study were to provide a model that might be of value to others interested in using VR in the teaching process and to enhance the literature on this important topic.

Internal SOC Efforts Leading up to the Present Study

The SOC Commander, Brigadier General Gerald Goodfellow, commissioned a SOC team to work with a VR software applications development team (AGS in Huntsville, AL) to build a unique VR software application entitled *Welcome to Studio X*. This immersive, 360-degree HMD-based scenario uses VR as a medium to explain the vision for how SOC intends to use VR and other educational technologies as a part of the Air Force-wide Officer PME Transformation initiative. In the course of building the *Welcome to Studio X* application, SOC further cemented a key strategic relationship with the development team at AGS (Army Gaming Studio), a well-known name throughout the gaming industry. Since 2002, AGS has developed virtual world environments via 2D display for the US Army to educate, train, and recruit soldiers through the proprietary gaming platform, “America’s Army.” The platform has experienced a worldwide user base of over 15 million users in its 15 years of existence.

The *Welcome to Studio X* application, was formally unveiled at Corona Fall 2015 as a part of the Air University Commander’s presentation to the top leadership of the Air Force to demonstrate one of the technologies being investigated for use in Air Force Professional Military Education (PME). Upon positive reception by the Air Force Chief of Staff and other top leaders, along with endorsement to further investigate the technologies, the SOC Commander conducted group sessions with SOC Stakeholders to explain efforts underway in integrating these leading-edge technologies into the SOC learning environment. The sessions communicated the leadership’s desire for Stakeholders to engage with the technology hands-on, to personally reflect on their engagement, and to conduct further self-directed research. The Commander further emphasized the value that Stakeholders’ formal input would have in SOC’s quest toward the technology integration vision.

After Stakeholders had attended a session with the Commander regarding his intent of the program that was aptly branded by the technology integration team as the “VR in Education Challenge,” the VILL subject matter experts provided workshops in which *Welcome to Studio X* and other VR applications were used to explain the use of immersive technologies and technical aspects of how VR works. During these workshops, Stakeholders used the technology hands-on and engaged in collaborative discussion on potential connections to the SOC curriculum. Based on questions asked, the sessions fluctuated in duration from 30-90 minutes each and varied in subject matter discussed depending on the experience background of individual Stakeholders in attendance at each session. Upon conclusion of the VR demo sessions, Stakeholders went away with leads for resources to explore during their self-directed inquiry and were advised of the intent for a follow-up questionnaires to be administered to solicit their inputs on challenges, opportunities, and practical applications for integrating VR into the SOS curriculum. Likewise, Stakeholders were advised of possible future research steps that may include semi-structured interviews.

Participants

The overall populace for the present research was the group of people whom SOC had previously engaged as participants in the internal program labeled the “VR in Education Challenge” [N = 37]. SOC leadership chose to administer that program among “SOC Stakeholders” of which component groups included SOC instructors, educational administrators, staff members, and prior students – all as further described in the following section. The present research provided equal opportunity for 100% of the target population to have the option to participate in the questionnaire instrument. Of the total N = 37, there were 27 participants [73%] who opted to complete the questionnaire. From among the 37 Stakeholder participants, selection to interviews (10) was made based upon analysis of the questionnaire data as well as subsequent discussion between the researcher and the SOC key informant. The analysis of questionnaire data indicated strong orientation toward experiential learning, leadership commitment, problem solving exercises, and affective domain learning areas. The criteria for selection for the interviews included choosing Stakeholder participants who had functional ties to curriculum in the areas indicated by the questionnaire data (experiential learning, problem solving, logistics, etc.) Another aspect considered in selecting interview participants included looking at individual levels of involvement vis-à-vis development of the Virtual Innovations Learning Lab to ensure that interviewees were familiar with the background of the program.

These criteria were used to capture the background story on the essence of the "lived experience" at SOC during the "VR in Education Challenge" and the VR integration journey. Demographics were also considered in the selection of interview members to ensure that each target population segment (or Stakeholder sub-group) was accounted for in the interviews.

Research Questions

1. Central focus: (Negatives & associated inverse positives) – Challenges and surmounting strategies anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

   Q1a. What are the potential challenges to integrating VR into the SOC learning environment?

   Q1b. What strategies/ideas could be used to overcome these potential challenges?

2. Central focus: (Positives) – Potential opportunities anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

   Q2. What are the potential opportunities for SOC in using VR as a learning tool?

3. Central focus: Practical applications of VR identified by SOC Stakeholders as having best potential to improve learning outcomes:

   Q3. What VR content (current or future applications) would have the most impact on SOC student learning?

Data Sources

Immersive Technology in Education Questionnaire (ITEQ). The ITEQ protocol was developed in collaboration between the researcher and the SOC Program Manager/Key Informant to collect data from the "VR in Education Challenge" participants (questionnaire protocol shown in Appendix 5). The researcher met with the SOC Program Manager on multiple occasions on the subject of questions for the ITEQ and formulated the ITEQ questions to correspond directly to the overall research questions.

The voluntary ITEQ instrument was administered to n = 27 SOC Stakeholders who had previously participated in the Commander's "VR in Education Challenge" in the course of their normal duties. The fact that all key Stakeholder groups participated in the ITEQ provides triangulation of sources to the original baseline data.

The ITEQ instrument consisted of 11 total questions and the instrument was sent to each volunteer participant by the SOC survey administrator as an email with the survey attached as a Microsoft Word Document. The first 5 questions were primarily demographic to provide criteria to use in describing the population. Questions 6 through 11 were open-ended questions that gave the participants space to type as much information as desired in furnishing their answers. Within the 6 open-ended questions, each question afforded a tool for the participant to address some component of the questions addressed by the research. For example, question #8 addressed potential challenges of integrating VR and question #6 addressed potential applications that would support the curriculum. Each person took from 15 to 45 minutes to complete the instrument, depending upon how much information they chose to share. Once the questionnaires were submitted to the SOC program coordinator, the submissions were thereafter referenced only by number. The survey program administrator pledged complete anonymity and beyond the administrator, no other person had the ability to attribute the survey data back to any individual participant.

Semi-structured interviews. Given that the SOC curriculum development process includes a committee structure that presides over curriculum in each primary area, the researcher, in collaboration with the SOC Key Informant, extended an invitation to previous "VR in

Education Challenge" participants who also serve on the targeted curriculum committees to further participate in the semi-structured interview. The researcher then coordinated with the volunteering committee members (who also were SOC instructors or leaders) to identify convenient times for the 10 semi-structured interviews.

Prior to the interviews, the coded synthesis of ITEQ data was used by the researcher to inform the initial baseline semi-structured interview protocol (shown in appendix 6). The ITEQ data analysis indicated target curriculum areas in which VR may provide the greatest opportunity to enhance learning outcomes. These target areas became the subject of "drill-down" prompts that were made available by the interviewer as a list to provide interviewees the opportunity to reflect on the data provided during the questionnaire phase and to further elaborate on areas that had been brought-up in the questionnaires. Conducting interviews as a separate method from the ITEQ provided triangulation of methods beyond just the open-ended questionnaire. The 10 semi-structured interviews were audio recorded and subsequently transcribed.

Just as with the ITEQ questions, the semi-structured interview questions were targeted toward the individual aspects of the overall research questions. Prompts included questions such as, "What challenges can you envision that SOC will have in the effort to integrate VR as a learning tool?" and "How can SOC best insure success in using VR as a learning tool?"

In addition to using questionnaires and semi-structured interviews, the researcher initially had built-in the option of using a focus group as a third source of data if required. In fact, the focus group route was included in the initial IRB protocol and was approved. However, in the process of analyzing the data from the questionnaires and the interviews, it was found that the point of data saturation had been well established. In other words, most of the replies collected in the interviews had already been provided as part of the questionnaire phase. It became evident that the population had adequately given the data needed to answer the research questions without asking SOC to allocate the additional hours of commitment required to conduct a focus group. Choosing to eliminate the focus group portion of the research was discussed between the primary researcher, the dissertation chair, and the SOC key informant. After thorough consideration of the matter, it was determined that given the point of data saturation had indeed been accomplished already, omitting the focus group would be the right course of action.

Data Analysis of the ITEQ & Semi-Structured Interview data

The researcher used ATLAS.ti Qualitative Data Analysis Software (QDAS) to perform data analysis of the ITEQ submissions and interview transcripts. From the initial coding of the ITEQ, the same qualitative data analysis code list was continued through the transcribed interviews. In the code list, the researcher added codes as they were developed through the research process.

In ATLAS.ti, the data were coded using themes which enabled all correspondingly-coded records to be sorted collectively. Upon collectively sorting each iteration of data by themes, the researcher analyzed the coded data again to ensure all records were applicable to their coded themes (Friese, 2012).

> "Initial Coding is breaking down qualitative data into discrete parts, closely examining them, and comparing them for similarities and differences … to remain open to all possible theoretical directions indicated by your readings of the data" (Saldaña, 2009, p. 81).

In conducting the initial coding (first cycle) of data, there was no pre-set group of codes in order to enable emergent "in vivo" codes to arise.

"In vivo Coding refers to 'that which is alive' and as a code refers to a word or short phrase from the actual language found in the qualitative data record, the terms used by the participants themselves" (Saldaña, 2009, p. 74).

As these key terms used within the ITEQ submissions were noted, the in vivo phrases directly from the participants' ITEQ submissions were added to the code list. The extraction of these codes – with origin directly from participants' words – provided a valuable starting point for subsequent analysis of data. A notable example of an in vivo code that persisted throughout the coding process was the code provided by one participant's ITEQ input in which he/she noted, "Why virtual at a live course?"

The first cycle – and all subsequent data coding throughout subsequent research phases also made use of Constant Comparison Coding.

Constant Comparison Coding: "…involves searching for similarities and differences by making systematic comparisons across units of data" (Bernard & Ryan, 2010, p. 58).

Throughout the process of first-cycle coding, once a code was assigned three times, each time that code was subsequently assigned, the new instance was compared to at least three previous instances of that code. This process, according to Bernard and Ryan "… keeps the researcher focused on the data rather than on theoretical flights of fancy" (p. 58). In other words, in order to keep consistency in applying a code, constant comparison coding ensured a triangulated cross-check every time the code was applied.

"Provisional Coding establishes a predetermined 'start list' set of codes prior to fieldwork. These codes can be developed from anticipated categories or types of responses/actions that may arise in the data yet to be collected" (Saldaña, 2009, p. 120).

In consideration of how to code ITEQ data, the researcher started with the research questions to create the baseline set of Provisional Codes. In addition to the in vivo codes developed during the ITEQ data analysis process, the initial Provisional Code set was as follows:

CHALLENGE: Potential challenges to integrating VR at SOC
(Pertains to research question 1a.)

OVERCOMING: Potential methods to overcome challenges or detriments
(Pertains to research question 1b.)

OPPORTUNITY: Potential opportunities for SOC in using VR as a learning tool
(Pertains to research question 2.)

AF-WIDE: Ideas for VR experiences that could be applicable throughout the Air Force (beyond just the scope of SOC or Air University)
(Pertains to research question 2.)

APPLICATION: VR applications to be acquired or designed based on curriculum
(Pertains to research question 3.)

"Simultaneous Coding is the application of two or more different codes to a single qualitative datum, or the overlapped occurrence of two or more codes applied to sequential units of qualitative data" (Saldaña, 2009, p. 62). Throughout each phase of data collection, simultaneous coding was used. If a particular datum from the ITEQ, or the interviews happened to be pertinent to two separate codes, both codes were designated using the ATLAS.ti coding tool – and were further connected to similar codes via themes. This method enabled subsequent analysis to bring-forward a single datum in regard to either/both codes (or corresponding themes) when needed.

“Structural Coding applies a content-based or conceptual phrase representing a topic of inquiry to a segment of data that relates to a specific research question used to frame the interview” (Saldaña, 2009. p. 66).

“Descriptive Coding summarizes in a word or short phrase – most often as a noun – the basic topic of a passage of qualitative data” (Saldaña, 2009, p. 70).

“Thematic Coding … is a phrase or sentence that identifies what a unit of data is about and/or what it means … an abstract entity that brings meaning and identity to a recurrent patterned experience…” (Saldaña, 2009, p. 139).

The coding process also made use of each of the three coding methods mentioned above: structural, descriptive, and thematic. Some codes became evident because of a conceptual phrase (for example “APP EXPERIENTIAL: SPACE OPERATIONS”); other codes were made evident due to a descriptive topic (for example: “CHALLENGE: PHYSIOLOGICAL FACTORS”). Then, other codes were more relevant to a theme (for example: “OPPORTUNITY: FACULTY DEVELOPMENT USING VR”). Because using multiple different types of coding was decided upon before conducting the analysis, it allowed the researcher to remain flexible in the analysis process.

Second Cycle Coding: Once data were coded during first cycle coding, it became apparent that certain codes were more frequent, while certain codes were rarely used. This discovery led to the need to conduct a second cycle coding.

“Focused Coding searches for the most frequent or significant Initial Codes to develop the most salient categories in the data corpus and requires decisions about which initial codes make the most analytic sense” (Saldaña, 2009, p. 155).

By identifying some of the most frequently used codes, it became apparent that some of the codes that were used just once or twice could be logically connected to some of the more frequently used codes; also, some infrequently used codes could be combined into a single code.

"Pattern codes are explanatory or inferential codes, ones that identify an emergent theme, configuration or explanation. They pull together a lot of material into a more meaningful and parsimonious unit of analysis. They are a sort of meta-code. Pattern coding is a way of grouping those summaries into a smaller number of sets, themes, or constructs" (Saldaña, 2009, p. 152). This concept was implemented using the ATLAS.ti function of "code groups" which corresponded directly with the researcher's schema of "themes."

A meaningful sub-unit level of coding was developed within the question pertaining to "APPLICATIONS." This sub-unit code level related to the different types of "EXPERIENTIAL" APPLICATIONS. Within each of those codes, this lower-level of coding pattern enabled subsequent analysis to be more meaningful (e.g. "APP EXPERIENTIAL: FLYING OPERATIONS," "APP EXPERIENTIAL: SPACE & CYBER OPERATIONS," or "APP EXPERIENTIAL: OPERATING ROOM").

The researcher also used ATLAS.ti QDAS tools to code the qualitative data (transcripts) from the interviews based upon emerging themes. Coding of the Interview transcripts proceeded in accordance with the same process as the ITEQ data. The researcher used ATLAS.ti and the same code list with codes already developed through the ITEQ. New codes were added as needed as additional concepts were identified in the interviews that had not previously been discovered in the ITEQ data.

The researcher then used the interview coded data along with the ITEQ coded data and analysis to produce a synthesis report that amalgamated both qualitative data sets (ITEQ, and interviews.) The researcher coordinated the synthesis report with another VR subject matter expert (SME) for analyst triangulation. Subsequently, an analysis and critique session was held with the SME in which a consensus of understanding on the report was obtained. The researcher then produced the final report. The synthesis report of results was included in chapters 4 and 5 of the dissertation and submitted to the SOC Commander and to multiple Air University Curriculum Development officials for future use in informing future Air University officer PME policy and curriculum development efforts.

Procedures

The research procedures used in this study were characteristic of those conventionally used in qualitative case study research. Prior to conducting the research, all aspects of the research procedures were briefed and vetted with the researcher's doctoral dissertation committee. Upon obtaining committee approval, the researcher then submitted for and obtained Auburn University IRB approval for the proposed research plan. Since the research subjects and institution being studied were subject to U.S. Air Force and Air University oversight, the IRB process also included approval by the U.S. Air Force Human Research Protection Office and the Air University Office of Academic Affairs.

While the Squadron Officer College is internally authorized to collect certain data on its own behalf, a portion of the research, the ITEQ questionnaire, was administered as an internal SOC initiative. After the SOC internal initiative of administering the ITEQ was complete, SOC voluntarily provided those data to the researcher who offered the courtesy of analyzing the data, both as a service to support SOC, as well as in the interest of accomplishing the present research study. Since the ITEQ was completed under SOC's authority – and under exemption to IRB requirements as an educational institution conducting routine internal inquiry on educational practices, the Auburn IRB granted the researcher a partial waiver of informed consent to use that portion of the data collection effort when those anonymized data were provided to the primary researcher. Throughout the research, the ITEQ data remained anonymous.

Upon analyzing the ITEQ data in accordance with the procedures described in the section, "Data Analysis of the ITEQ & Semi-Structured Interview data" above, the researcher compiled a report that articulated the most commonly identified responses broken-down by primary research question. That report was used as a list of prompts provided to participants during the semi-structured interviews.

The researcher coordinated with the SOC Key Informant in identifying the key personnel within the population of SOC Stakeholders who had participated previously in the Commander's "VR in Education Challenge." Each of the participants identified was known as a key contributor to some aspect of the SOC curriculum development process, the SOC leadership process, or the SOC technology integration process. Each of the potential participants was contacted in person first by the Key Informant to inquire on their desire to participate in the interview, and then second by the researcher to arrange for a convenient time and neutral place to conduct the interview. Also, in advance of the interview, each informant was provided a copy of the Auburn IRB-approved informed consent letter to give them plenty of time to understand the terms.

In the beginning of each semi-structured interview, each interviewee was given a chance to read-over the Informed Consent Form again and offered the opportunity to decline participation as well as to ask any questions before deciding to sign. Each of the 10 participants eagerly signed two copies of the informed consent document: one for himself/herself, and one for the researcher's records.

As a semi-structured interview, the discussion for each interview preceded differently: depending upon the interviewee's area of expertise and focus. Interviews lasted for about 20 minutes on average, with the shortest lasting 15 minutes and the longest lasting 40 minutes. Upon completion of each interview, the interviewee was re-assured that all information would be kept confidential and their identity would remain completely anonymous. Interviewees were also advised that if they had follow-up questions, they could contact the primary researcher, the SOC key informant, or the Auburn IRB and those contacts were provided.

Interviews were subsequently transcribed using the "Rev.com" transcription service. In order to make sure each transcript was accurate, the primary researcher went through each recording along with its corresponding transcript and corrected any verbiage that the transcriptionist may have misspelled or mis-understood. Then, with 10 accurate, re-checked transcripts in-hand, the researcher entered each transcript as a new document into ATLAS.ti and conducted the coding process using the same coding conventions as used with the ITEQ data as described above.

Trustworthiness

Credibility. Andrew K. Shenton in the 2004 article, *Strategies for Ensuring Trustworthiness in Qualitative Research Projects*, outlined multiple areas of credibility in which a researcher should endeavor to account for. Following is a description of how this study addresses each of these areas.

"Well-established Research Methods" (p. 64) – The study utilized Open-ended Questionnaires, Semi-structured Interviews, and Multiple Coding Methods: each method is separately discussed previously within this chapter.

“Keen Familiarity with the Culture of the Organization” (p. 65): The researcher’s past experience afforded the standing of acceptance as an “insider,” a “native” or fellow warrior among service members who were students, instructors, and educational leaders within SOC. Insider research is known as research in which the researcher operates within populations of which they are also considered members (Kanuha, 2000). The researcher graduated from the SOS program in 1998 – which gave the researcher prior knowledge of the lived experience of an SOS student.

“Qualification & Experience of the Researcher” (p. 68): As an active duty colonel in the U.S. Air Force, the author previously served as an instructor and faculty member at the Air University from 2011 to 2013. Prior to serving at Air University, the author’s 20+ years of active duty service involved multiple levels of leadership in dozens of locations around the world in Mission Support career fields (Personnel, Services, Base & Range Logistics, and Education & Training). Likewise, the researcher’s recent PME faculty experience enabled him to be acknowledged as well-qualified within the SOC faculty circle. This ability to be considered “a native” is important in qualitative inquiry, particularly during interviews due to the propensity for subjects to render acceptance to the interviewer and consequently be more likely to openly discuss their views on a subject.

“Rational Sampling Techniques” (p. 65): All prior participants in the “VR in Education Challenge” received an email from the SOC Program Manager inviting them to complete the optional open-ended questionnaire and return it by email. This approach resulted in a very strong response rate of 73%. After analysis of the questionnaire data, the researcher met with the SOC Key Informant to discuss the curriculum areas that had indicated the strongest concentration of significance related to the research questions. Then, members of pertinent curriculum committees (who also had previously been involved in the “VR in Education Challenge”) were invited to further participate in interviews. Both methods of sampling (100% opportunity for the survey, and purposeful selection for the “live” sessions) are well-founded in educational research practice.

“Ensuring Honesty in Informants” (p. 66): The first core value of the Air Force is “Integrity” – which entails being honest; thus, core values have to be upheld at all times by military professionals. As each informant in the study was an active duty officer (as was the researcher), a fundamental assumption in this study is that informants have been honest in expressing their ideas, beliefs, and attitudes.

“Frequent Debriefing Sessions” (p. 67): Throughout the course of the research, the primary researcher met at least bi-weekly with the SOC Program Manager/Key Informant for routine debriefing on the research to-date and bi-monthly with the SOC Commander, Vice Commander or Dean of Academics for debriefing to leadership on recent key milestones and advisement on forthcoming research activities. Additionally, the researcher met at least monthly with other key VR experts at Air University to keep these external interests apprised of how the research was developing and listen to suggestions. Finally, the researcher maintained an ongoing dialogue with the dissertation committee chair in regard to progress of the research process.

“Peer Scrutiny of the Project” (p. 67) and “Member Checks” (p. 68): No less than 5 educational technology experts within Air University stayed closely in the loop on the research as it progressed.

“Thick Description of the Phenomenon under Scrutiny” (p. 69) and “Examination of Previous Research” (p. 69): Chapter 2, Literature Review of this report details substantial analysis, evaluation, and synthesis of the multiple dimensions of Immersive Technologies applied to Education.

"Triangulation" (p. 65): The study accounted for triangulation of methods (both questionnaires and semi-structured interviews), triangulation of sources (multiple stakeholder groups), triangulation of analysts (the coded analysis from each method was member-checked with two other VR experts); triangulation of theory/perspective: while some aspects of the study are from a pragmatic theoretical perspective (direct applications of VR); some aspects are from a rational philosophical perspective (challenges and opportunities); and others take-on a humanist philosophical outlook (self-guided research on VR by each individual prior to completing the questionnaire). The following table demonstrates the extent to which research questions are triangulated to multiple data sources.

Table 2

Data Sources Triangulated to Research Questions

Data Source Matrix: Case Study on Integration of Immersive VR and AR Technologies at USAD Air University's Squadron Officer College		**Products to be Analyzed**	**Analysis Method**	**Relevant Research Questions**		
				Q1: Challenges (and Surmounting Strategies) to VR Integration	**Q2: Opportunities for Integrating VR**	**Q3: Practical VR Applications**
Interactive/Verbal Data Sources	Semi-Structured Interviews	Ten Recorded interviews + transcripts +field notes	**ATLAS.ti QDA software**: Detailed version next diagram	✓	✓	✓
Written Data Sources	"Immersive Tech in Education Questionnaire" (ITEQ) administered to 60+ stakeholders	Digital text data: all recorded responses to questionnaires: 7 open ended questions and 5 demographic questions	**ATLAS.ti QDA software:** Detailed explanation provided on next diagram	✓	✓	✓
Extant Literature				✓	✓	✓

Table 3

Data Analysis Method Summarized

Data Source	***Methods of Systematic Data Analysis***	***Data Source Output to Analysis of Other Sources***
"Immersive Technology in Education Questionnaire" (ITEQ administered electronically internally to 27 stakeholders participating in the VR Education Challenge: all computer-input responses to questionnaires provided as raw data to the researcher; 6 open ended narrative questions & 5 demographic questions	1. Read through date with provisional codes on hand to determine suitability to the data set, modifying major codes as needed. 2. Using the established codes, created master codebook relating the codes to corresponding research questions. 3. Used ATLAS.it to code all the narrative data; determined if number and specificity of themes was right; added new codes as needed 4. Used ATLAS.it to "cut and sort" data into themes 5. Looked for patters among thematic groups and relationships between demographics to themes. Evaluation at this level informed the results section & provided input to next phase (interviews and focus groups)	Based on analysis of ITEQ coded data, researcher identified target curriculum areas for best likelihood of using VR for learning. SOC Stakeholders & Staff connected to those targeted areas were invited semi-structured interviews. ITEQ coded data also used to fine-tune questions for interviews
10 Semi-structured recorded interviews: Transcripts made of recordings + field notes	1. Transcribed each interview; reviewed each recording to double-check transcript and based on field notes, added margin notes to transcripts 2. Ran ATLAS.ti word count to identify primary themes among the transcript and field note data 3. Compared the world count output to the master code book; as new themes began to emerge, new codes were added 4. Used ATLAS.ti to "manually" code the interviews and field note data 5. Used ATLAS.ti to "cut and sort" data into themes 6. Identified patterns among themes and relationships between demographics to themes. The evaluation at this level informed the results section and provided input to the next phase.	Analysis from the semi-structured interviews was combined with analysis of ITEQ data to serve as the basis for informing the final synthesis report (Chapter 4 – Results and Chapter 5 – Conclusions)

Transferability. From identifying the resources to be used in the study to evaluating the end results in chapters 4 and 5, all parts of the research were interpreted through the Instructional Systems Development (ISD) model in order to enable transferability to other PME programs or higher education entities who employ ISD or a similar model. Each of the practical suggestions for using VR was related back to time-honored educational and social science theories and as such should provide important foundational information for other higher education institutions seeking to use VR as a learning tool. The study also harnessed the data collected by SOC Stakeholders to demonstrate a better understanding of the nature of VR technology applied in the PME sector of higher education.

Higher education institutions who are interested in integrating a new technology (such as VR) into their programs may find transferability of the model used in this case study. Educators, or other professionals, who are interested in potential positive and negative aspects of implementing VR technology may be able to transfer these recommendations from the report as to answer many of their questions.

Since the study involved examining the establishment of the first-ever VR learning lab to use consumer VR in a leadership education arena, leadership development programs may find aspects of the study to be transferrable. The Virtual Innovations Learning Lab (VILL) became the "think-tank" used for investigating opportunities for using VR as a learning tool with particular emphasis on opportunities for experiential learning; thus, educational enterprises aspiring to magnify concentration on experiential learning may find these aspects of the study transferrable.

Higher education programs interested in a stakeholder involvement model in curriculum design may be able to transfer aspects of the study relating to stakeholder involvement. This unique stakeholder-involvement case study model for both researching the nature of a new technology while simultaneously implementing the technology "live" into an organization can serve as an exemplar for studying and implementing a new technology within the Air University's other colleges. Likewise, this case study model may also be transferable to non-military institutions who endeavor to integrate a new technology (such as VR) into the learning process.

Dependability. Dependability in qualitative research relates most directly to whether or not the research could be repeated in the same way by another researcher (Creswell, 2013). The outcome of a study like this would probably be different at an organization other than the Squadron Officer College since so many aspects of SOC are unique. However, given the diagram on the next page that very clearly delineates each step of the process followed in this study, it is likely that any researcher qualified in conducting qualitative research could repeat the process.

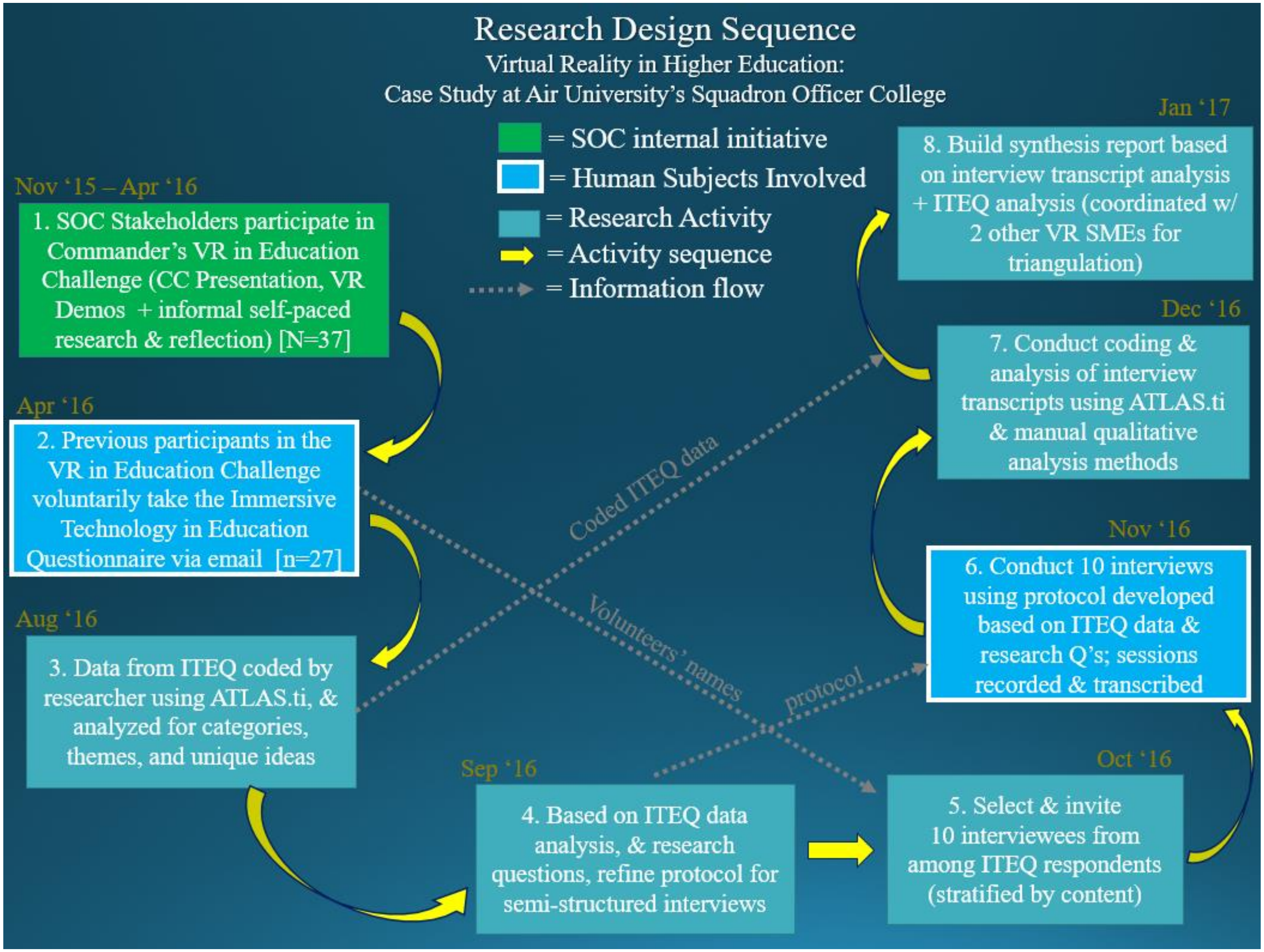

Figure 6. Research Design Sequence

Confirmability. "… confirmability (vs. objectivity) is based on the acknowledgment that research is never objective. It addresses the core issue that findings should represent, as far as is (humanly) possible, the situation being researched rather than the beliefs, pet theories, or biases of the researcher" (Morrow, 2005, p. 252).

In the effort to assert this study as being confirmable, on average of once per week during the research process, the researcher met with the SOC Key Informant, who holds a doctorate degree from George Washington University in Higher Education Administration and has advised on several doctoral dissertation committees. One of the subjects of the meetings was always whether the researcher was following what the data says and not being side-tracked by personal biases. While the researcher candidly discloses interest in the field of Immersive Technology, his key perspective on the research was to evaluate the challenges and opportunities of VR as an educational tool. To this effect, the integration of VR into the learning environment must be done in synch with what Stakeholders had truly experienced from it – not only the positives, but problem areas as well. In addition to weekly meetings with the SOC Key Informant, the researcher kept several other key mentors and colleagues informed on the research for feedback and peer checks.

Lastly, given the clearly delineated plan as noted in the next page – as mentioned throughout the dissertation, the researcher followed the plan just as set-out. The fact that the research "stuck to the plan" is an aspect to confirm that the researcher was faithful in conducting the research.

Ethical Considerations

Surmounting potential diminished autonomy. The research included efforts to avoid the potential for diminished autonomy to be considered a factor. SOC students can be considered as participants with diminished autonomy given that they are under the supervisory authority of SOC cadre: as such, the researcher chose not to use students as subjects. Given that 41% of research subjects had all been SOC students within the past 5 years, and 78% within the past 7 years, it was considered that the student perspective as a SOC Stakeholder group could be adequately represented from within the population of "VR in Education Challenge" participants (and concurrently active research participants). Likewise, SOC instructors and staff members are under the authority of SOC senior leadership and may be considered to have diminished autonomy from that regard. By making the questionnaire completely voluntary, the research provided the ability for anyone who would prefer not to participate to choose not to complete the questionnaire. Further, within the questionnaire, each individual question was optional; thus, subjects were free to omit any portion that they chose not to complete. Subjects were informed that individual names would not be used in the final research report. In the final report, any name references made for clarity were done pseudonymously. (Stakeholders 01-27 were ITEQ participants, while Stakeholders 28-37 were interviewees.) The informed consent document unambiguously explained that participants may terminate their involvement in the research at any time and that their personally identifiable information would not be used to attribute their inputs to them directly. Upon arrival at the interview session, subjects were informed that the data collection and reporting would refer to them pseudonymously throughout so that their personal identity would not be linked with any of their inputs.

Availability of Military Personnel. A 72-hour window was provided to complete the ITEQ instrument so that military participants could proceed with their normal duties and turn in the final submission at a convenient time. Interviews were scheduled at a time that did not conflict with the interviewees' military duty requirements.

Private data acquired from willing subjects.

- Position or relationship with the Squadron Officer College

- Date graduated from SOS (if an SOS alumnus)
- Military rank/civilian grade/contractor status
- 4-digit Air Force Security Code - AFSC (or equivalent for non-USAF officers)
- Highest level of formal education
- Personal views on challenges & opportunities of integrating VR into SOS curriculum
- Ideas for possible direct application of VR into SOS current or future curriculum
- Name and contact info: particularly if they chose to self-nominate to participate in interviews.

Security of private data. Original survey data received via emailed Microsoft Word files were saved onto the researcher's hard drive as Microsoft Word files and subsequently deleted from the recipient's email inbox. While server backup versions of those files could have potentially remained, no effort was made nor ever will be made to connect the original data back to individual contributors. Using the Word files from the researcher's hard drive, the survey data were copied and pasted into a Rich Text Format (.rtf) document to be used in the data analysis phase of research. Transcripts of the interviews were produced as text documents using the online transcription service, Rev.com. The transcript data were stored on the same hard drive as the survey Outlook files and kept by the principal investigator. All analysis of the qualitative data was accomplished on the researcher's PC which was kept password protected. During data analysis, no effort was made to directly attribute individual inputs back to the originator.

Disposition of private data. The principal investigator designated himself to transfer the master hard drive files to CD-ROM, delete the data from the hard drive, and keep the original data, all working files, analysis files and any other pertinent data on the master CD-ROM for the time stipulated by IRB.

Indirect benefits. Benefits of the study will be to the Air Force graduate PME population and to the higher education populations at-large. By developing a better understanding of applying VR to Education, the accrued benefit recognized will be to advance the use of these technologies in improving educational outcomes.

Types and probabilities of risks. The qualitative risk was only in regard to the small likelihood that negative comments voluntarily made by a participant would somehow be leaked and attributed back to the originator resulting in negative repercussions. Tight controls on the data were enacted to prevent this from occurring (i.e. deletion of the original email files from the key informant's inbox, only storing the completed electronic survey and transcript data on a master hard drive maintained by the principal investigator.) Given the nature of SOC being an academic entity where academic freedom is a core value, even in the remote case of original data being compromised, the likelihood of attributing negative comments back to the originator was minimal. Moreover, if such connection occurred, the institutional predisposition for this type of connection at SOC has is that of attributing minimal significance. Even the most bizarre views imaginable on the subject of applying VR to Education would most likely result in zero retribution to the individual if accidentally attributed.

Summary of risks versus benefits. Building a better understanding of how to integrate VR into the graduate PME learning environment will provide long-term benefits that far outweigh the minimal risk. In the context of progressing graduate PME and graduate education at-large in the direction of using VR as a learning tool, the knowledge to be gained from this research is of substantial benefit. The research design and safeguards in place provided careful consideration toward eliminating risk from the population to include minimizing the chances of negative comments being attributed to an originator. The minimal risk of negative attribution was rendered further inconsequential in light of the policy and tradition of non-attribution in place within SOC and Air University.

Chapter Three Summary

This chapter presented an analysis of the research methods used in the Case Study at the Air University's Squadron Officer College in integrating Virtual Reality. In the chapter, the methods used for administering the Immersive Technology in Education Questionnaire (ITEQ) were presented. Also, the methods involved in coding the qualitative data were described. The in-person data collection methods: the semi-structured interviews, were described in this chapter. Also, the chapter analyzed aspects of trustworthiness of the dissertation which included credibility, transferability, dependability, and confirmability. Finally, the chapter discussed several ethical considerations that were taken into account through the study. The next section, chapter 4, will provide an analysis of the results from the study. Finally, chapter 5 will discuss the conclusions that can be drawn from the study as well as suggestions for further research.

Chapter IV: Data Analysis and Results

"Not everything that can be counted counts, and not everything that counts can be counted."

-- Albert Einstein, Physicist

This qualitative intrinsic case study sought to better understand the process of integrating Virtual Reality as a learning tool by obtaining the essence of the subjective views and professional inputs from a purposeful cross-section of Squadron Officer College (SOC) Stakeholders who participated in the Commander's "VR in Education Challenge." The data provided by this group of SOC Stakeholders was in the form of qualitative open-ended questionnaires known as the ITEQ and recorded semi-structured interviews conducted by the researcher that were subsequently transcribed. Both the ITEQ inputs and the interview transcripts were input into the ATLAS.ti qualitative data analysis software and analyzed by the primary researcher. The results of the data analysis were presented in this chapter.

Purpose of the Study

The aim of this research was to inform the Air University policy process, curriculum development efforts, and instructional practices on strategies to enhance and support the integration of VR into the graduate PME learning environment. The study sought to identify the elements that would be potential challenges, means to overcome challenges, and opportunities for integrating Immersive Technology into the learning environment and to synthesize a compilation of potential VR applications with relevance to PME and grounding in time-honored educational and social science theories. These challenges, opportunities, and applications should provide important foundational information for other higher education institutions seeking to use

VR as a learning tool. Further purposes of the study were to provide a model that might be of value to others interested in using VR in the teaching process and to enhance the literature on this important topic.

Description of the Population

The chosen population for conducting the present study was identified as the overall population of SOC Stakeholders. Within the greater population of SOC Stakeholders exists a sub-population of Stakeholders who participated in the internal initiative called the Commander's "VR in Education Challenge." Stakeholder involvement in the direction of innovation within an educational enterprise is a valuable notion. The Air University Strategic Plan provides institutional backing for involving Stakeholders in ways such as that used by the present study: "Success requires that Stakeholders embrace the vision, mission, lines of operation, goals, and objectives described … and contribute their energy and expertise to those ends" (AU Strategic Plan, 2015, p. 5). The idea of fostering buy-in from those who will be involved in or affected by the organization's investments, policies, and strategic direction is a well-established precept. The stakeholder groups who participated in the "VR in Education Challenge" (and more specifically the present research) are described as follows:

SOC Instructors: the majority of the participants in the "VR in Education Challenge" were SOC Instructors. This is a selectively-chosen position, and to be selected as a SOC Instructor, an Air Force officer must be a graduate of SOS in-residence, in the grade of captain or major, and have a strong record of performance as a leader. Also known by the title of Flight Commander, SOC Instructors have an average of 8 years of post-bachelor's active duty leadership experience in any one of over 120 Air Force officer career specialties. While serving as Instructor/Flight Commander, they are assigned the responsibility of developing a group of 14 SOS captains in each 5-week SOS session. Given the high student production nature of the in-residence SOS program (over 500 graduates in each session), SOC instructors are intensely focused on classroom instruction, facilitation, and mentorship of students 8 or more hours every day, five days each week throughout the 5-week session. Through their faculty development program, SOC instructors gain a thorough understanding of principles of instruction as well as expanded subject matter expertise in the areas of leadership and communication. The unique blend of a diverse variety of career specialties combined with robust preparation as battle-ready instructors makes the corps of SOC Flight Commanders an ideal group from whom to solicit inputs regarding the worthiness of a new education technology platform being applied to the curriculum.

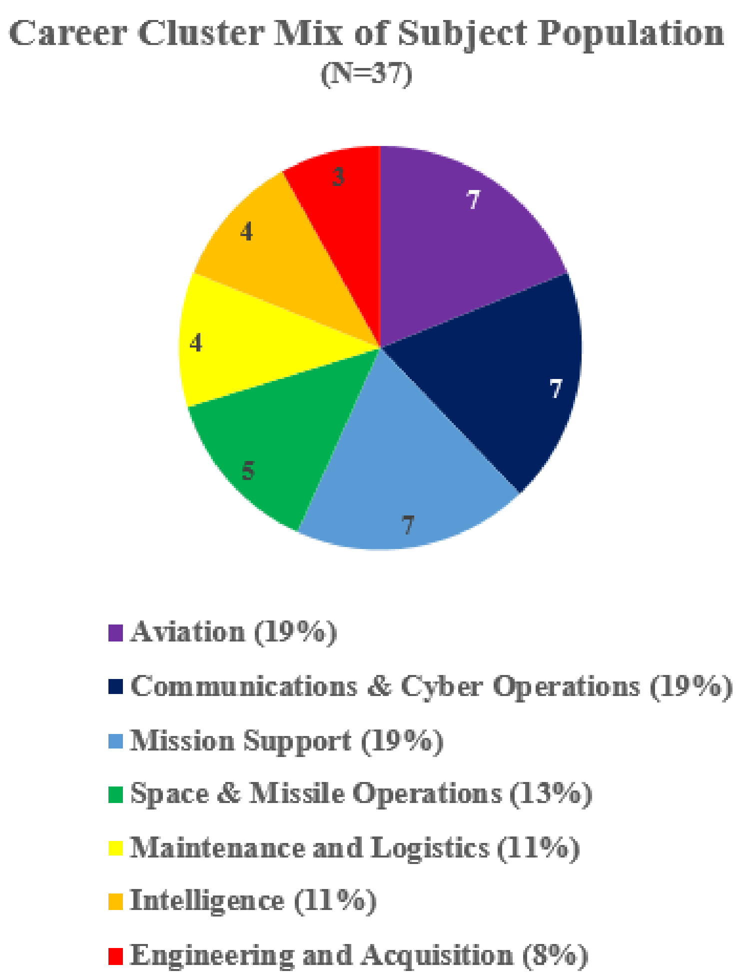

Figure 7. Career Cluster Mix of Subject Population

SOC Command Leaders: There are eight flights in each SOC squadron. Squadron Commanders are officers in the grade of lieutenant colonel, with an average of 16 years' active duty leadership experience. In addition to Squadron Commanders, the "SOC Command Leaders" stakeholder group includes other senior officers (lieutenant colonels and senior majors) filling positions within the SOC leadership team. Also, highly trained and from a diverse spectrum of career specialties, SOC Command Leaders do some in-classroom instruction; however, their perspective has traditionally been more toward strategic leadership, supervision of people, and managing resources. Seven subjects from within the study, or 21% of the participants were representatives of the stakeholder group, "SOC Command Leaders."

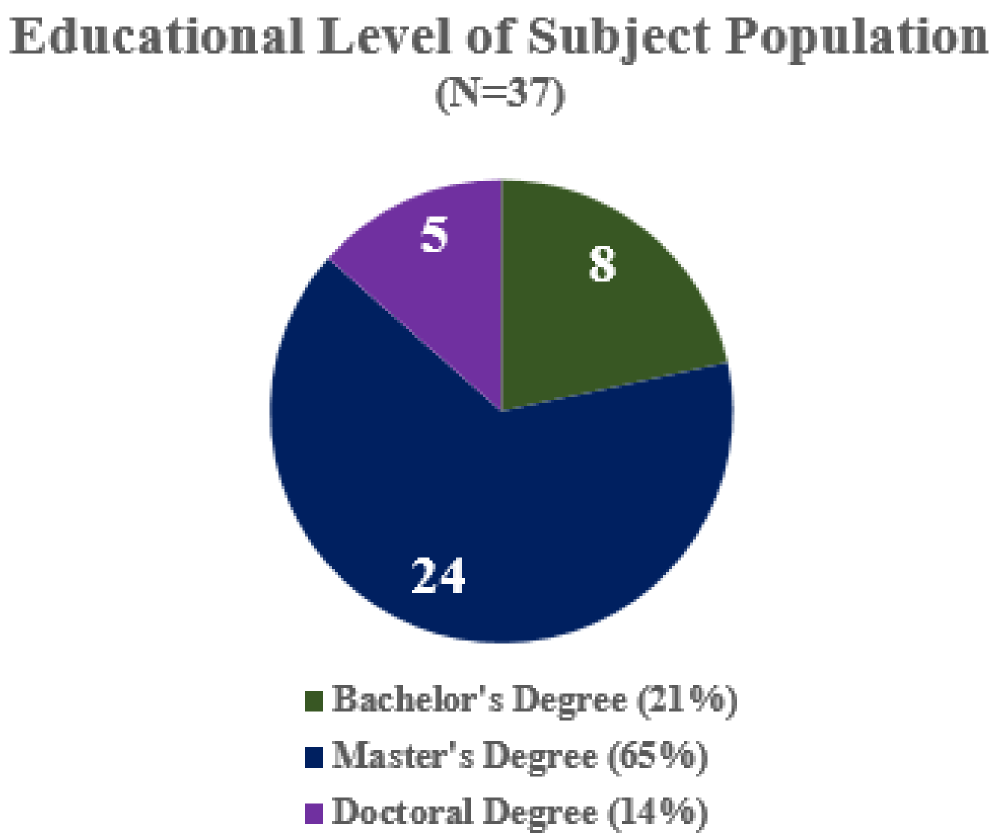

Figure 8. Education Level of Subject Population

SOC Civilian Professors and Civilian Leaders: Doctoral-degreed civilian professors of SOC play a key role in strategic curriculum oversight and manage the process of identifying curriculum material relevant to SOC educational outcomes. Several of these Stakeholders are colloquially referred to as "SOC Docs." Like other professors in higher education, SOC civilian professors have responsibilities in teaching, research, and publishing. Likewise, other Civilian Leaders at SOC with highly-specialized credentials play key roles in the academic success of the organization. Within the stakeholder group, "SOC Civilian Professors and Civilian Leaders," there were four participants, or 11% of the overall population who provided qualitative data collected for the study.

SOC Mission Support Professionals: These staff members serve various roles supporting the academic mission within the college and include mid-level civilian and military personnel. Logistics, Facilities Management, Athletic Administration, and Human Resource Management are examples of the roles played by this group of Stakeholders. Within this stakeholder group, there were 12 representatives, or 32% of the population.

SOC Students: past, present and future: Among the most critical stakeholder groups in regard to any type of curriculum change is the population to whom the curriculum is targeted to educate: students. Just as alumni at any adult/higher education institution have a vested interest in the improvements made at their alma mater, SOC students from the past want to know that the college is continuously improving. From the perspective of SOC alumni, the study has them well-represented in the population: all but one ITEQ participant (96%) were graduates of SOS in-residence. From the perspective of current students, a few important drawbacks existed to involving students directly in the study. First, because students are only at Maxwell for five weeks, the ability to follow-up with students or involve them in subsequent parts of the study would be substantially constrained due to their limited time availability. Second, given the unique nature of students feeling perhaps "compelled" to participate, the neutrality or sincerity of student's opinions may be suspect. Third, the in-residence SOS program is exceptionally rigorous and, as such, SOC leadership prefers to avoid using students in research unless a suitable alternative cannot be identified. In this regard, and in keeping with well-established precedent at SOC, a suitable proxy for current students was identified: those who had been students in recent years.

Among the "VR in Education Challenge" participants who volunteered to complete the ITEQ, six participants (22%) completed SOS in residence within the past three years. Also, eleven (41%) had completed SOS within the past five years. A total of 21 participants (78%) had served as an SOS student seven years ago or less. For the perspectives that we were looking for in this study (challenges and opportunities of implementing VR into the curriculum and practical applications for VR), the researcher, in collaboration with the Key Informant, the SOC Dean, and the SOC Vice Commander, determined that the perspective of having been a SOC in-residence student recently would be sufficient to represent the stakeholder group of present and future students. Thus, in accordance with well-established precedent at SOC, recent graduates fulfilled the role of representing their respective primary stakeholder groups as well as providing input on behalf of the "Student" Stakeholder group.

Research Questions

1. Central focus: (Negatives & associated inverse positives) – Challenges and surmounting strategies anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

   Q1a. What are the potential challenges to integrating VR into the SOC learning environment?

   Q1b. What strategies/ideas could be used to overcome these potential challenges?

2. Central focus: (Positives) – Potential opportunities anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

   Q2. What are the potential opportunities for SOC in using VR as a learning tool?

3. Central focus: Practical applications of VR identified by SOC Stakeholders as having best potential to improve learning outcomes:

   Q3. What VR content (current or future applications) would have the most impact on SOC student learning?

Question 1a. Challenges to Integrating VR into the SOC Learning Environment

Through analysis of the ITEQ and interview data, three overarching themes emerged around potential challenges to integrating VR into the SOC learning environment. First, participants consistently talked about technology challenges and how those would impact the ability of using VR, particularly while VR is still a nascent technology in the education arena. Second, participants talked frequently about how a number of challenges would be related to how leadership approaches the endeavor. And, the third theme of challenges identified through the data were curriculum challenges.

Theme 1a.1 – Technology-based challenges to integrating VR. The first theme of challenges to integrating VR relates to the nature of technology. SOC Stakeholders who responded to both the ITEQ questionnaire as well as the semi-structured interview consistently pointed-out multiple technology-based issues that would serve as challenges along to road to using VR as a tool within the learning environment (and likewise any other new piece of technology.)

In the outset of describing this data analysis, it is important to point-out a key caveat to these results and, in particular, the charts displayed. The caveat was that the number of times a code was applied does not necessarily account for an “X-times more or less important” of a factor than any other code in that group. While the number of times each code was applied has been displayed in the charts throughout this chapter, the reader should keep in mind that this was done to illustrate that the factor was clearly brought forward as a theme – our “grounded.” It in no way should be interpreted as a measure of “exactness” on how much more or less relevant one factor may be compared to another. Factors that were not identified by participants at least three times were typically not identified as a theme. Important “stand-out” factors that were infrequently cited were noted as part of the narrative in this chapter.

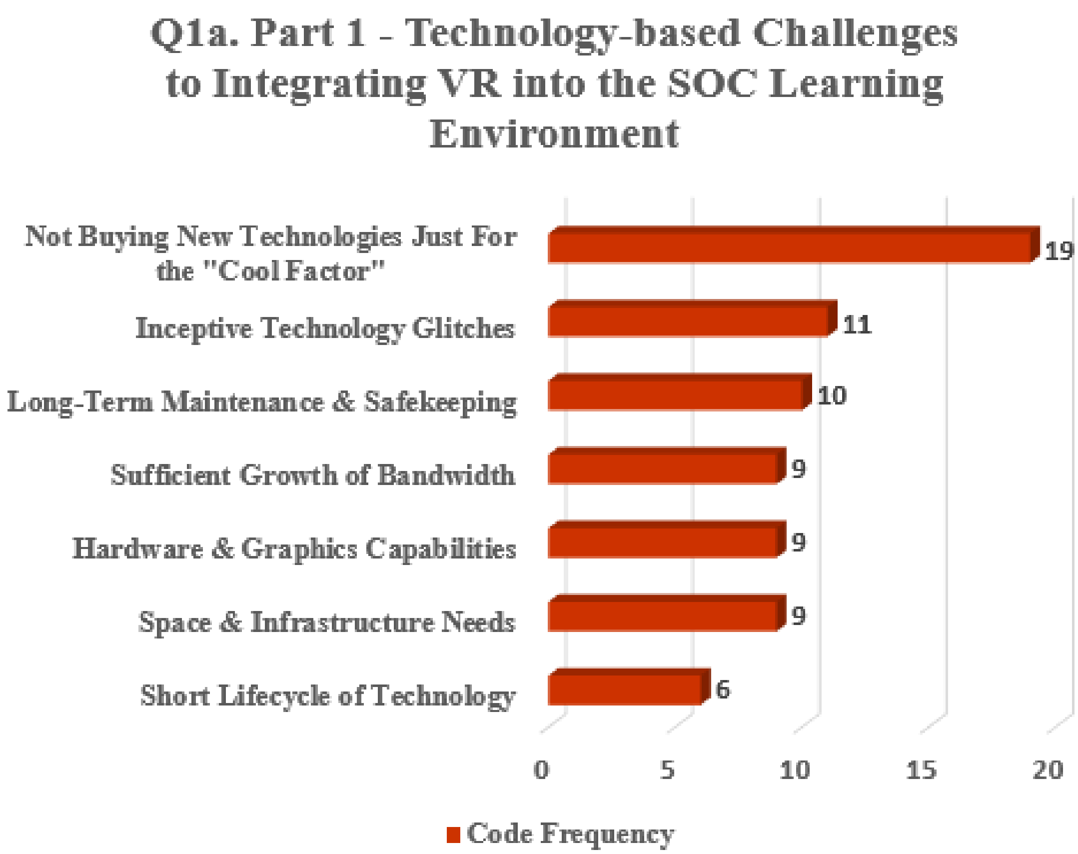

Figure 9. Technology-based challenges to integrating VR

One of the main concerns that SOC Stakeholders expressed is that acquiring “technology just for the cool factor” is an effort that could cause the organization to seriously lose focus.

Very consistently throughout the questionnaires and interviews, SOC Stakeholders warned of this point. Some sample statements related to this finding were:

- "TECHNOLOGY JUST FOR THE COOL FACTOR"
    - "Don't chase VR for the sake of being 'cutting edge'. Education and leadership isn't about technology fads, it's about teaching people how to think and work with real people if VR doesn't do that better than talking to 13 fellow captains in a flight room, then you're detracting from your primary purpose" (Stakeholder 22).
    - "VR is just a tool, a means to accomplish teaching and educating our customers. It's important that this institution not forget to identify the desired outcomes of using a VR environment, and then be able to show measurable value towards achieving those outcomes. Technology can be very exciting because it is new. I believe that we must balance that excitement, innovation and interest with showing value-based output in line with our institutional purpose and mission" (Stakeholder 26).
- "INCEPTIVE TECHNOLOGY GLITCHES" as a challenge to VR integration is another main category of findings from the data. Unlike other technology attributes that can be planned for, equipment malfunctions (glitches) literally turn people off from the technology. In the beginning phases of using a piece of technology (hence the word "inceptive" being used as part of this code), it is often unknown exactly what glitches are going to occur.
    - According to one SOC leader, "If you mess it up three times, it's a piece of crap and they don't want to see it again … they'll take (it) back because the technology gave them resistance when they went to adapt it" (Stakeholder 38).
- "LONG-TERM MAINTENANCE AND SAFEKEEPING" was consistently cited in the data as a challenge to be dealt with:

- “(VR is) … expensive to maintain & keeping someone around employed that knows how to fix & operate the equipment … that won’t run off to the next high paying job.” (Stakeholder 21).
- “One also has to consider the fidelity of the hardware and the long-term maintenance costs/requirements to sustain such a capability for SOC. Hardware can crash or break, written lesson plans or live role-playing exercises in the classroom don’t really do that” (Stakeholder 23).

- Beyond the long-term maintenance and safekeeping of the actual VR equipment, since VR in its current state requires a substantial amount of bandwidth, the issue of “GROWTH OF BANDWIDTH” was firmly grounded.
  - “Not everybody is going to have an Oculus or a Vive; you’d have to have a way for them to come to a central location like an education center where you have devices for people to experience. That would still be problematic because of limited bandwidth. Say, if you have 10 or 20 of them at a location, that’s still limited” (Stakeholder 28).
  - “We have .gov computers and that limits what we can do. Our commercial internet bandwidth is limited due to cost” (Stakeholder 02).
  - “The exercise crashes our network pretty handily with just 8-9 people using it” (Stakeholder 14).
- Another technology-based challenge was coded as the factor of “HARDWARE & GRAPHICS CAPABILITIES”
  - “The VR world will need to mirror current graphics and user integration to get the most buy-in from students. We are past the point where Nintendo N64 graphics for a 3D world is will suffice” (Stakeholder 05).

- "The most difficult part of such a VR application would be the cost of creating accurate and detailed imagery" (Stakeholder 19).
- "Technology is the biggest factor. You can't expect that all students will arrive with a compatible laptop to run the required VR applications" (Stakeholder 25).
- "And the quality cut that's there goes back to what we said earlier: our students don't suffer poor technology. So, you can't short-cut it. (Stakeholder 32).

• "SPACE & INFRASTRUCTURE NEEDS" was highlighted as a technology-based challenge to integrating VR:
  - "I think finding a suitable space for VR lessons and/or equipment will be a challenge. I believe all the currently unoccupied flight rooms are needed for larger classes so there aren't any free flight rooms" (Stakeholder 27).
  - "Careful foresight and planning on how to ensure SOC isn't weighed down with complex, expensive, broken systems" (Stakeholder 06).
  - "How many headsets do I have? How many pieces of equipment? We get 550-600, how many students can I run through at one time? What if it breaks – what's my backup? A lot of our outdoor stuff, indoor stuff, I don't even need electricity. As long as there's enough light coming through the window we can still run our stuff" (Stakeholder 37).

• The final factor within the theme of technology-based challenges to integrating VR as a learning tool included "SHORT LIFECYCLE OF TECHNOLOGY"
  - "SOC would also commit itself to assimilating to the culture of the rapid technology cycle, which is to say, continually adapt early and quickly or become irrelevant (i.e. '2000-and-late')" (Stakeholder 23).

- "Technology Limiting Factor is a huge concern. What may work today may not tomorrow and vice versa" (Stakeholder 01).
- "The students are accustomed to the newest thing on the commercial market- the military is always several years behind technologically, so we look elementary compared to what they are accustomed to using" (Stakeholder 02).
- "Virtual training & education is most likely not equal in effectiveness to traditional face-to-face; older technophobes will avoid it and older leadership won't understand it and thus not fund it. It will become obsolete quickly and need to be replaced every 3 years or so" (Stakeholder 21).

Theme 1a.2 – Leadership-based challenges to integrating VR. The second key code group under Question 1, "Challenges to Integrating VR as a learning tool," corresponded to the theme of Leadership-based Challenges. These codes were related to factors in which the organization's leadership would play the primary role to address. To best ensure success, SOC leadership would place these factors as a strategic priority.

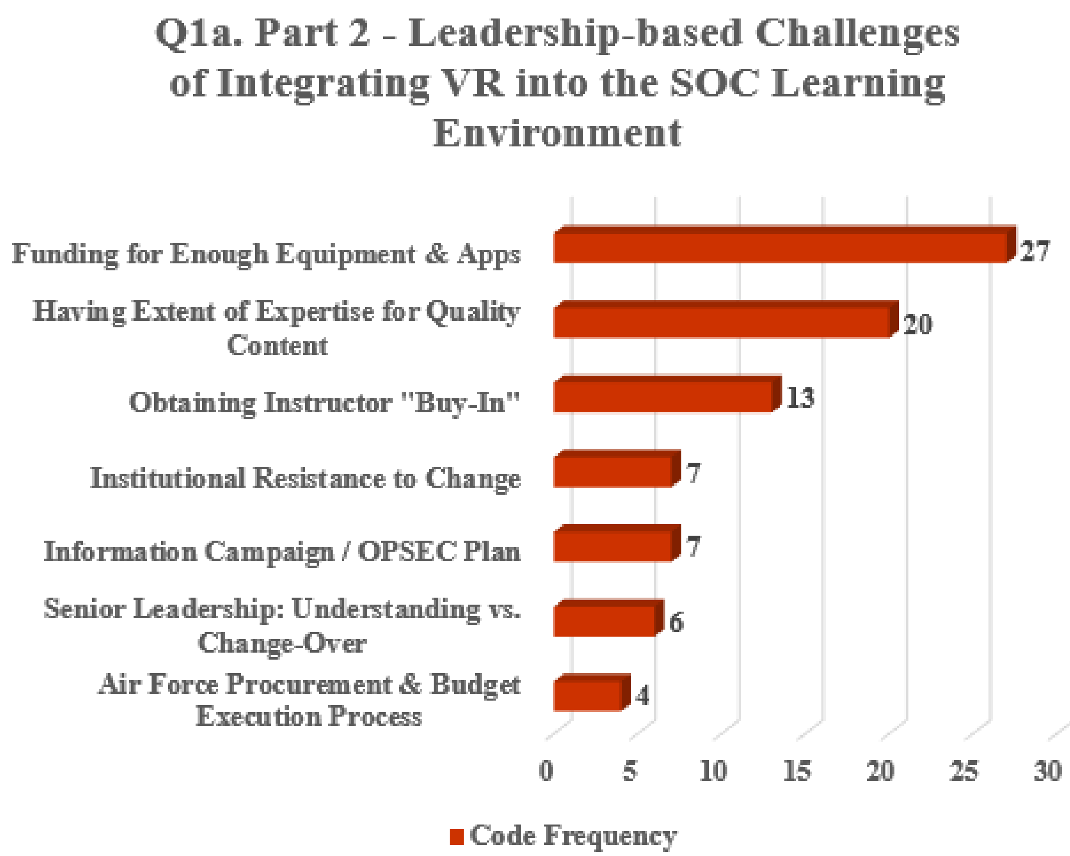

Figure 10. Leadership-based Challenges of Integrating VR

- The first of these Leadership-based challenges included the factor "FUNDING FOR ENOUGH EQUIPMENT & APPS." Examples of data provided to support this factor included:
  - "Accepting glitches or rushing through a solution that isn't really production ready, or has been done on the cheap. Both these items will negatively impact faculty acceptance and student willingness to "try the new thing" because it will feel like a bad gov't attempt to copy/do what major corporations (Oculus, Samsung, HTC, Microsoft, etc.) do with multi-million dollar budgets (Stakeholder 06).

- "I think budget to acquire enough VR devices for the students could be an issue. The cost of developing the VR tools/programs/applications could be prohibitive (Stakeholder 27).
- "These are not cheap to produce. So you want to make sure you understand the gaps in the curriculum where "a lot of students don't get this point." What can we do so they "get it?" (Stakeholder 29).
- "With current resources and resourcing of the systems, I'm skeptical that we can organically change "leadership education" with VR teaching in the residence course (Stakeholder 06).
- "Budget: 1. How do we effectively balance the cost applied to exploratory research vs. towards specific endeavors? 2. Can we actually afford enough headsets for even a single squadron to use at a time? (Stakeholder 13).
- "Budget (we don't have the money to fund enough of these for the school to use), and connectivity—the exercise crashes our network pretty handily with just 8-9 people using it" (Stakeholder 14)

Each of the remaining codes used in the "Leadership-based Challenges" theme is detailed below in ALL CAPS, followed by example statements made that fit into the Leadership-based Challenges theme:

- "HAVING EXTENT OF EXPERTISE FOR QUALITY CONTENT"
  - "Adequate support may need to be provided by an in-house, expert contractor. We can't expect to buy this equipment and hope we have enough tech savvy flight commanders on staff to support the technology out of hide" (Stakeholder 19).

- “As the requirement grows, there needs to be the right quantity, and quality of personnel to design, develop, operate and sustain the VR capabilities at SOC, which likely will be scaled in some way across Air University” (Stakeholder 26).
- “As far as who’s going to be developing this content, people with game design experience are going to be at the forefront of content for these platforms – whether it’s AR, VR, whatever, they all use the same technology like the Unity Engine, the Unreal Engine, and having that game development experience will benefit you whether you’re making a video game or not” (Stakeholder 31).

- “OBTAINING INSTRUCTOR ‘BUY-IN’”
    - “If instructors fully support this initiative then students will buy-in too. I think this has to be the pivotal first step before students even see it. I get the feeling that there are some nay-sayers out there (Stakeholder 05).
    - “I know a number of people that are on this installation that are very esteemed educators who think this is actual crap. Because, they haven’t seen the level of application where they think it’s meaningful” (Stakeholder 32).
- “INSTITUTIONAL RESISTENCE TO CHANGE”
    - “The biggest challenge will be change resistance. I believe we’ve already seen this with the roll-out of edX and other portions of the Integrated Learning Environment. We’re our own worst enemy when it comes to innovation and change” (Stakeholder 08).
    - “A lot of them are still in the mindset that they need to “teach” and their students need to learn the way that they learned – and the way that they were taught. That has been probably our biggest hurdle in moving forward at AU” (Stakeholder 30).

- “The cultural barriers are somewhat weakening. The learning curves are starting to flatten out a little bit. People are not “balking” as much to change. They are starting to see, “Hmm, I may want to try some of that.” Whereas, before, not just, “no,” but, “I don’t need that in my classroom.” That doesn’t fit who I am” (Stakeholder 30).

- “INFORMATION CAMPAIGN/OPSEC PLAN”
  - “We know this isn’t the case and that we’re just implementing something that better caters to student learning, but it won’t come off that way unless we figure out how to sell/advertise it” (Stakeholder 08).
  - “I am excited that it’s being considered, but also want badly for its introduction to be successful to prevent negative anchoring” (Stakeholder 06).
- The factor of “SENIOR LEADERSHIP: UNDERSTANDING VS. CHANGE-OVER” was developed with the convergence point being a balance: while it takes time for senior leaders to develop a full understanding of the programs and put a vision into practice, the Air Force assignment rotation system also typically requires leadership change every 2 years which shortens the amount of time available for a program to sustain focus under a single senior leader.
  - “Build a guiding coalition. If you're alone and trying to make change, you're done. I mean the boss can say, "Do it." But as soon as he's gone it could go away” (Stakeholder 37).
  - “Most of your leadership don't fully understand the capabilities. They may have gotten a really cool demo and think that you can just do that and sometimes it's harder than it looks” (Stakeholder 38).

- AIR FORCE PROCUREMENT & BUDGET EXECUTION PROCESS"
    - "I'm cautiously optimistic. We're on the cusp of a potentially revolutionary change in how to train or educate. With current resources and resourcing of the systems, I'm skeptical that we can organically change "leadership" education with VR teaching in the residence course" (Stakeholder 06).
    - "I like the idea; I don't have faith in the AF procurement & execution process" (Stakeholder 04).

Theme 1a.3 – Curriculum-based challenges to integrating VR. The theme "Curriculum-based challenges to integrating VR" was identified as those challenges in which the key manifestation will be recognized from within the curriculum.

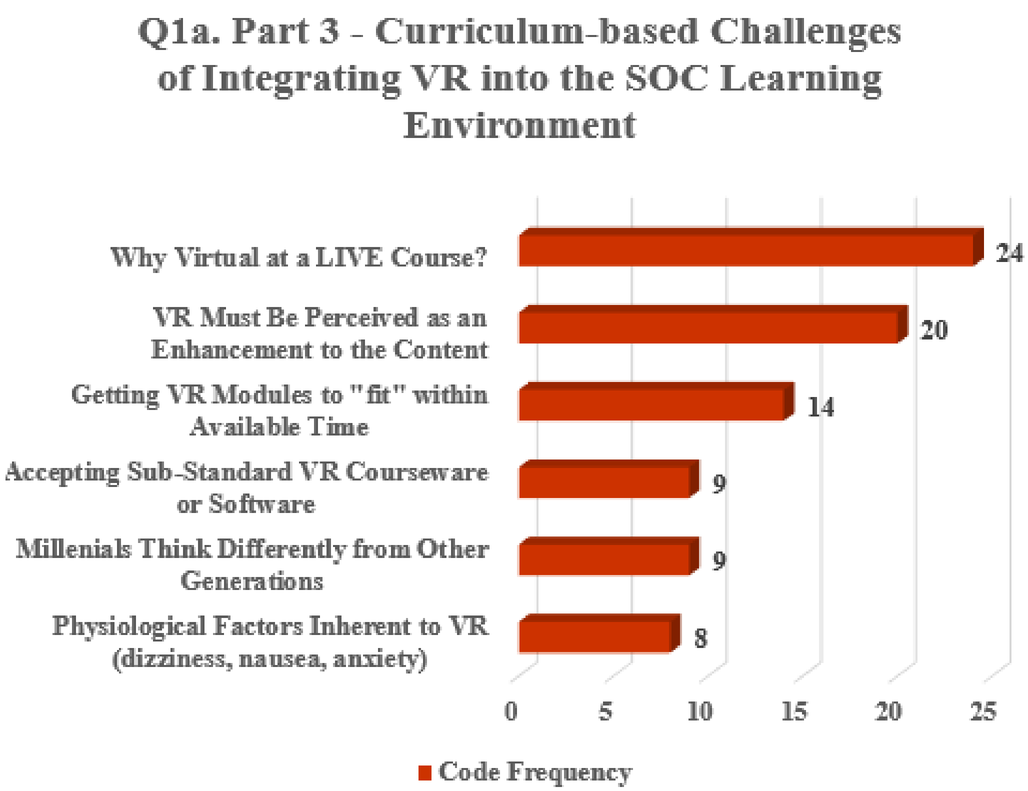

Figure 11. Curriculum-Based Challenges of Integrating VR

- The researcher chose to use an In Vivo Code “WHY VIRTUAL AT A LIVE COURSE?” since the exact words used by one of the research subjects most directly pointed-out the meaning contained within this code. This happened to be the most highly grounded code within the theme of Curriculum-based Challenges – and one of the most thoroughly grounded codes throughout the Question #2 set of themes. The idea that SOC Stakeholders expressed in this code is centered on the fact that usually, the goal of Virtual is to try to come close as possible to Real:
  - “The common theme among instructors when VR applications are provided to the students is ‘why did the AF spend thousands of dollars to send their Capts to an in-resident PME experience only to have them discuss and work on issues in a virtual environment’” (Stakeholder 03).
  - “If a common statement is millennials already have trouble with face-to-face interpersonal relationships, why would we be in the business of removing that challenge? It is what they face in their duties anyway.” (Stakeholder 03).
  - “With current resources and resourcing of the systems, I’m skeptical that we can organically change “leadership” education with VR teaching in the residence course (Stakeholder 06).
  - “Using technology to replace classroom activities gives the impression that we’re taking the lazy way out. We can contract someone to build a great VR system and then it relieves us from having to deal with the students during that block” (Stakeholder 08).
  - “This is an in-residence school; people may not understand the emphasis behind VR when we physically bring people here to conduct activities. I don’t believe that VR

should have a primary role within an in-resident course, it should simply be there to augment" (Stakeholder 09).

- "I think it could be a great supplement in the classroom, but not yet ready for full replacement of face-to-face education" (Stakeholder 21).

Additional factors used in the theme, "Curriculum-based Challenges to Integrating VR" have been identified in ALL CAPS, followed by examples of the data:

- "VR MUST BE PERCEIVED AS AN ENHANCEMENT TO THE CONTENT"
    - "It's important that this institution not forget to identify the desired outcomes of using a VR environment, and then be able to show measurable value towards achieving those outcomes. Technology can be very exciting because it is new. I believe that we must balance that excitement, innovation and interest with showing value-based output in line with our institutional purpose and mission (Stakeholder 26).
    - "All activities need to remain focused on flight development (team building, SWOT analysis, problem solving, etc). If they are not, then the students will wonder why they are here vs distance learning" (Stakeholder 25).
    - "You'd likely have to combat the stigma of "Computer Based Training on steroids" (and again back to…what is good enough? If a 2D video gets the job done for orientation, why invest in VR?" (Stakeholder 18).
- "GETTING VR MODULES TO "FIT" WITHIN AVAILABLE TIME"
    - "At SOC, with a 5-week course (the limited time we have), it will be challenging to find the holes in the curriculum, the right time in the curriculum to do these things" (Stakeholder 29).

- “There’s always political friction associated with dissolving or distilling other elements of the SOC curriculum, which would be necessary if there’s any legitimate aspiration to ADD anything else to the five-week course” (Stakeholder 23).
- “With regard to the big picture, I think at some point, if we would like to add some of these opportunities, we may need to lengthen SOS to 6 weeks” (Stakeholder 20.)
- “If I’m a pilot and I’m seeing this perspective versus I’m in a Hum-Vee and I’m seeing this perspective right now, or I'm in a minefield and I have this perspective; how do we encompass all of that within one VR? Do I think it's possible? Yes. Here's the even bigger challenge: how do I emulate that in this five weeks compressed schedule? So you have to be able to get a huge bang for your buck in a very compressed timeframe” (Stakeholder 36).

• “ACCEPTING SUB-STANDARD VR COURSEWARE OR SOFTWARE”
  - “What we found is that our students don’t suffer poor technology, but they use technology (again as a leverage point) to reach learning outcomes that perhaps they wouldn’t in any other case” (Stakeholder 32).
  - “There is a level of “cheese” that you have to avoid. If you do a simulation that is meant to convey an idea, but you’re using 3D assets from 10 years ago, that suspension of disbelief is less achieved” (Stakeholder 31).
  - “Technology can be very exciting because it is new. I believe that we must balance that excitement, innovation and interest with showing value-based output in line with our institutional purpose and mission” (Stakeholder 26).
  - “Half-baked or sub-standard software or courseware in the system. Accepting glitches or rushing through a solution that isn’t really production ready, or has been done on the cheap” (Stakeholder 06).

- “MILLENIALS THINK DIFFERENTLY FROM OTHER GENERATIONS”
  - “The challenge SOC has is that this generation needs to be pushed more into face-to-face interaction, not more virtual worlds and virtual friends. This technology may give too much room for Captains to continue to ignore interpersonal skills – the challenge is to ensure you’re complimenting the personal interaction, not replacing it” (Stakeholder 22).
  - “If a common statement is millennials already have trouble with face-to-face interpersonal relationships, why would we be in the business of removing that challenge? It is what they face in their duties anyway” (Stakeholder 03).
  - “I agree one problem may be that older students might feel they are at a disadvantage, but the vast majority of our students would do well” (Stakeholder 19).
- “PHYSIOLOGICAL FACTORS INHERENT TO VR (DIZZINESS, NAUSEA, ANXIETY)”
  - “For some people who have never been in VR, it’s like an overwhelming experience” (Stakeholder 29).
  - “Could there be physiological impacts? Not just ‘don’t like,’ but physically ‘can’t tolerate’ (e.g., dizziness, upset stomach, anxiety?)” (Stakeholder 07).
  - “There's some others that … would seem to get a little motion queasiness” (Stakeholder 35).

Question 1b – Strategies for Overcoming Challenges to Integrating VR

A defining characteristic of the pragmatic philosophical tradition is that inquiry is meant to solve problems and address new opportunities. As noted in the outset of this dissertation, while gaining better understanding of Virtual Reality was an aim of the present research, that understanding was not just for the sake of understanding, but also to applying that understanding for better education – and particularly, to improve PME programs within the Air University. As such, merely identifying challenges to the integration of VR in education was not sufficient (as per research question 1a.). A higher pragmatic aim was to identify ways to overcome these challenges of VR (the present section of this chapter – relevant to research question 1b.) – and even further, opportunities inherent to VR integration (next section – relevant to research question 2) – as well as specific applications of VR in education (relevant to research question 3 – the final section of chapter 4.)

Theme 1b.1 – Faculty-based strategies to overcome challenges. The SOC Stakeholder participants in the ITEQ and the interviewees were not reluctant to share their ideas on how to overcome the challenges they had articulated in the previous section. While not every single challenge was directly offset by a direct answer of "how to overcome" in answers to the immediately subsequent questions, many of the challenges, as will be depicted in the next major section, are more directly addressed in terms of particular "Opportunities." In other words, overcoming challenges is not always accomplished by attacking the challenge directly with a full-frontal assault, but often, the challenge is better overcome by engaging with opportunities whose effect may be to render a challenge irrelevant or moot. The following theme, "Faculty-based Strategies to Overcome Challenges" was one in which several strong factors were identified.

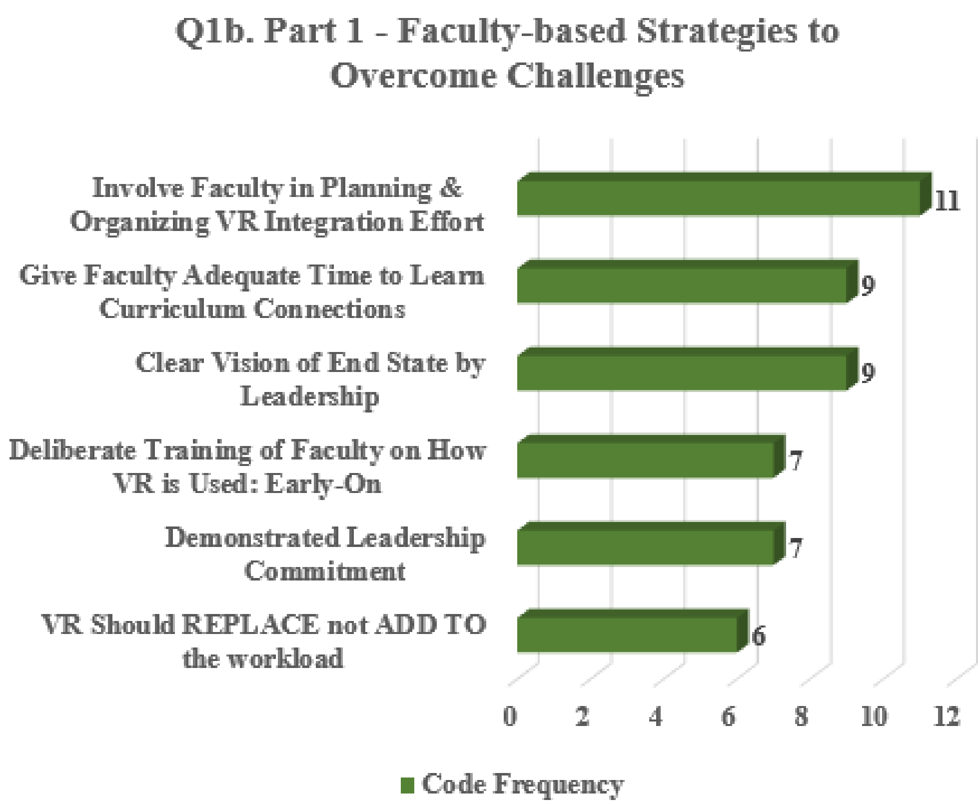

Figure 12. Faculty-Based Strategies to Overcome Challenges

- The first factor, "INVOLVE FACULTY IN PLANNING & ORGANIZING VR INTEGRATION EFFORT," was heavily supported. Research participants provided the following examples of inputs:
  - "Part of the introduction and roll-out of VR needs to be educating the instructor cadre and bringing them on board as soon as possible to create a sense of ownership. This doesn't mean just-in-time training during pre-week or several days prior to the event. I'm talking about deliberate training. Furthermore, you need to keep the instructors periodically updated on what you are doing. Don't hide this stuff in a dark closet somewhere and then just roll it out one day" (Stakeholder 08).

- "For the love of Pete, don't let your final comments during the sales pitch sound like this ... 'This is a great new thing; it has a wonderful impact on students and faculty alike. And, it's just a little more work for the instructors'" (Stakeholder 18).
- "… (engage) deliberate conversation between different branches of the school to determine what the balance needs to be" (Stakeholder 17).

Additional factors used in the theme "Faculty-based Strategies to Overcome Challenges" have been identified in ALL CAPS, followed by examples of the data:

- "GIVE FACULTY ADEQUATE TIME TO LEARN CURRICULUM CONNECTIONS"
  - "For faculty, we will have to schedule a lot of time and invest energy into every instructor so that they are comfortable to make all the curriculum connections and answer the FAQs students may have (Stakeholder 05).
  - "Building a corps of experienced and knowledgeable faculty to fully utilize the resource is crucial" (Stakeholder 06).
- "CLEAR VISION OF END STATE GIVEN BY LEADERSHIP"
  - "Give SOC faculty a clear vision of where you want this to go!" (Stakeholder 03).
  - "I think instructors need to know what the end state is" (Stakeholder 03).
  - "Develop and communicate a SOC Strategic Plan and ensure that only 'good ideas' are pursued if they fall in line with the overarching plan" (Stakeholder 16).
  - "You don't want to buy stuff and it show up with no plan. We have a plan with this particular product we did; that's just an example – there are lots of great products out there. Just buying it and hoping it's going to be what you want it to be is not a plan" (Stakeholder 29).

- “Our change efforts should be directed at increasing our educational effectiveness and we should have objective metrics to ensure that we are actually achieving that goal” (Stakeholder 13).

- “DELIBERATE TRAINING OF FACULTY ON HOW VR IS USED: EARLY-ON”
  - “This doesn’t mean just-in-time training during pre-week or several days prior to the event. I’m talking about deliberate training. Furthermore, you need to keep the instructors periodically updated on what you are doing. Don’t hide this stuff in a dark closet somewhere and then just roll it out one day. Send out updates via email. Brief us during pre-week. Let us know what’s going on” (Stakeholder 08).
  - “Train instructors how to use the equipment and fix it real-time” (Stakeholder 14).
- “DEMONSTRATED LEADERSHIP COMMITMENT”
  - “Develop and communicate a SOC Strategic Plan and ensure that only “good ideas” are pursued if they fall in line with the overarching plan” (Stakeholder 16).
  - “… consistent unwavering support from the Commandant” (Stakeholder 10).
- “VR SHOULD REPLACE NOT ADD TO THE WORKLOAD”
  - “If you have such a great product to infuse, be sure it REPLACES something that already exists. There are lots of agencies with great ideas and all summarize saying ‘and it’s just a little more work for the instructors’” (Stakeholder 18).
  - “In order to do the initiative justice, we need to make sure that we’re dedicating the right amount of time to it without taking away from the rest of the curriculum.” (Stakeholder 20).
  - “These Captains have better things to do than learn 3 different websites plus VR tech in the span of 5 weeks. Until you can figure out a way to vertically integrate all of this

technology into one platform that makes sense and doesn't require hours of tinkering to figure out, you're going to lose most of your target audience" (Stakeholder 22).

Theme 1b.2 – Non-faculty-based Strategies to overcome challenges. Within the research question 1b., "Strategies to Overcome Challenges," the second main theme was "Non-Faculty-Based Strategies." The defining factor for codes to be assigned to this group was that the overall impetus for action in these factors would be found primarily outside the teaching faculty. Within this theme, research participants provided robust contribution.

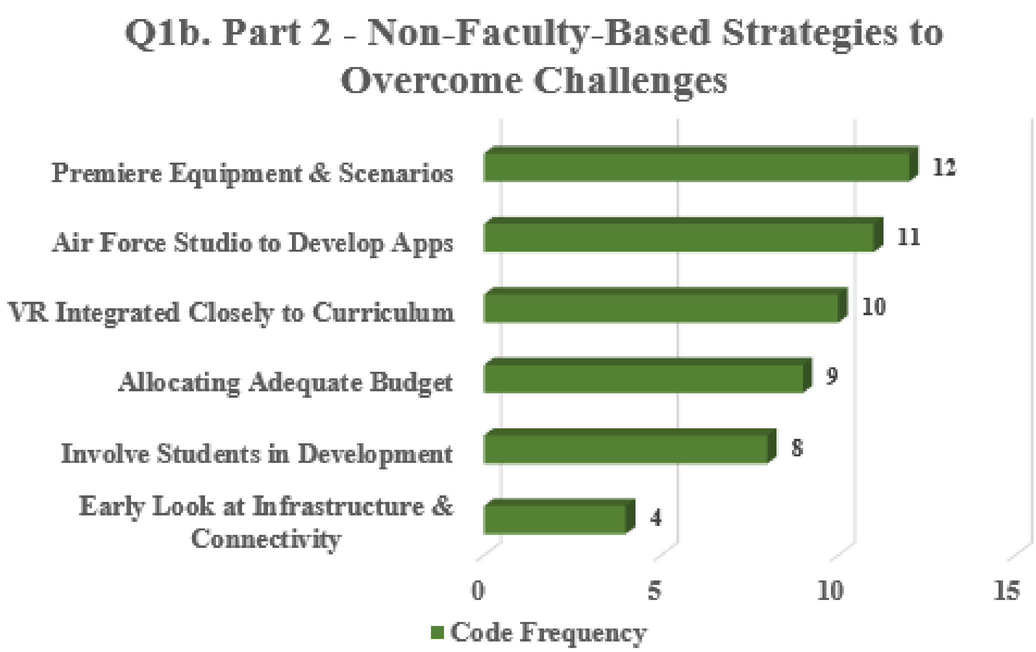

Figure 13. Non-Faculty-Based Strategies to Overcome Challenges

- To begin the "Non-Faculty-Based Strategies" theme, a very well-grounded factor was that of "PREMIERE EQUIPMENT & SCENARIOS." The data were consistent throughout the research that SOC Stakeholders support the notion of not doing VR at second-rate level:

  - "Invest more in our network availability to avoid crashes" (Stakeholder 14).

- “To counter the negative comments about needing to be here to use VR, we would need premier VR equipment and scenarios” (Stakeholder 02).
- “When it comes to people, it’s different than scenery. Re-creating body language, voices, and facial expressions: all of that stuff is really hard when it comes to content generation. Maybe in 10 years, that won’t be a problem anymore. We have crazy, crazy graphics cards now, especially with the invention of VR, they’ve been made out of necessity at this point to do all that stuff. But the suspension of disbelief is the most important part in that sense. So, we have to be careful when making content to make sure that we don’t disturb that” (Stakeholder 31).
- “I think a multiplayer Project-X activity would show a lot of value, because you could have more possibilities and scenarios to try for new experiences. Also, it may make it easier to try new ways to do Project-X type activities, such as dynamic team reshuffling, doing events with more than 6-8 students, or even doing competitive TLPs with one group of students against another group. There are a lot of possibilities in VR that are not currently available in Project-X (such as the competitive team vs team idea)” (Stakeholder 26).

- The second factor, “AIR FORCE STUDIO TO DEVELOP APPS” was suggested several times. Research participants provided inputs that support the idea of having a studio with staff who have technical skills to develop VR applications:
  - “The AF needs to learn how to design these kinds of experiences. How that fits into VR. I read an article recently where they’re trying to figure out how to make VR movies. It’s a totally different production; you can’t have people behind the camera. You have to think differently about how you do these things” (Stakeholder 29).

- “The Unity Engine, the Unreal Engine, are both open-source engines, so whatever is not available in its inventory, you can add to it by making whatever you want. The people with the know-how are at the forefront of this. It behooves content developers, or someone who wishes to be a content developer to learn how to do this stuff” (Stakeholder 31).
- “I would say ISD is the Air Force learning bible; ISD needs to address VR – we’ve got a lot to learn about that. Where we’re working is on the cutting edge of using VR for Education – and training, maybe. I don’t know what other people are doing with that, but lessons-learned have to be learned about how you build it. … You cannot build a $50,000 – $100,000 game if it doesn’t tackle the right problem. You’ll waste your money” (Stakeholder 29).
- “We should expand this out – prototype something – and see if it applies to us. As an Air Force, I feel like it’s necessary to take risks like that. … If you took a handful of content developers who want to see this succeed, they will drive that initiative forward. If they’re given a task, they’ll accomplish it. It all hinges on acceptance of the technology and it all hinges on clear and concise goals for them to meet. But before we start looking at that, we need to have an infrastructure or an organization in place to set all that up so that (educators) can come to this ‘development studio’ and say….’I want you to build this for me.’ Then, with the infrastructure in place to do it, we can use the “Agile Manifesto” (programming architecture) to assign work and code these things. It’s something that we could easily spin-up if given the “go-ahead” (Stakeholder 31).

Additional codes used in the theme, "Non-Faculty-based Strategies to Overcome Challenges" have been provided in ALL CAPS, followed by examples of the data that fit within each factor:

- "VR INTEGRATED CLOSELY TO CURRICULUM" – after close consideration, this factor was placed into the "non-faculty challenges" theme since more of the subject data related to the non-teaching curriculum development side than to the curriculum delivery.
  - "You want to design it to be integrated with the curriculum if you have an in-residence program. If you want a stand-alone, that's a different story. For us, we want to try to integrate it into SOC – into the curriculum" (Stakeholder 29).
  - "This is a really powerful tool if it's used appropriately with the right purpose and really integrated into the curriculum" (Stakeholder 33).
- "ALLOCATING ADEQUATE BUDGET"
  - "Invest more in our network availability to avoid crashes" (Stakeholder 14).
  - "I think we have to be honest about the full cost to adequately support any VR technology. Adequate support may need to be provided by an in-house, expert contractor. We can't expect to buy this equipment and hope we have enough tech savvy flight commanders on staff to support the technology out of hide" (Stakeholder 19).
  - "The Plan must include flexibility to obtain the right talent/skills at the right time, for the desired purpose" (Stakeholder 26).
  - "VisiCalc really helped for the hyper-proliferation of the computer. But, that's what VR needs on the education side. They need the killer app. And, once the killer app exists in education; once that's unlocked, then, everything else will change. Because then, industry, academia, everybody else will be able to go to their bosses, to their

money-feeders and say, “now you know why I need one,” and they’ll be like, “yeah, and I want one” (Stakeholder 32).

- “INVOLVE STUDENTS IN DEVELOPMENT”
  - “Push the resource to the students and let them help develop” (Stakeholder 15).
  - “Don’t wait for a perfect solution. Start employing VR immediately with the students and leverage their talents to improve it. Collectively they will have better ideas and understanding how to employ it more effectively” (Stakeholder 15).
  - “VR is going to rapidly changing our environment. Start incorporating the students in the process” (Stakeholder 15).
  - “In addition to assigning/directing a dedicated team of individuals, SOC should ensure this team has adequate representation from the customer perspective, or at least someone in the same age demographic. This goes for AU as well. If you’re trying to innovate with teams of people exclusively 35 and older then you’re omitting the entire cohort of digital natives and a significant segment of the SOC target market (i.e. its students)” (Stakeholder 23).
  - “They want to get in there and roll their sleeves up and be a part of it, and if you give them an opportunity, you will not have a nodding head in that room. They want to get so involved, we’ve seen where even after they graduate, they want to be a part of what this means in the future” (Stakeholder 30).
- “EARLY LOOK AT INFRASTRUCTURE & CONNECTIVITY”
  - “Look at infrastructure connectivity and behind the scenes requirements early” (Stakeholder 04).
  - “Invest more in our network availability to avoid crashes” (Stakeholder 14).

Question 2 – Opportunities for SOC in Using VR as a Learning Tool

The next main research question, Question #2, relates to "Opportunities for SOC in Using VR as a Learning Tool." Opportunities often serve to solve problems that correspond to particular challenges; however, the biggest success is when an opportunity creates an entirely new classification of success – one in which previous problems did not correspondingly exist because no one knew what was even possible. Within Question 2, there were 4 themes:

1. Factors attributed to *the Phenomenon of VR*
2. Factors attributed to *Use Cases of VR*
3. Factors attributed to *Unique Stakeholder Groups*
4. Factors *applicable Air-Force-wide*

Theme 2.1 – Factors attributed to the phenomenon of VR: opportunities. The first part, "Factors Attributed to *'The Phenomenon of VR'* are factors that related to the actuality that VR is indeed different from any tool that has ever been used for education. The participants' inputs within this section demonstrate that there are things about the phenomenon that takes place whenever a person puts himself/herself as first-person into the "VR space."

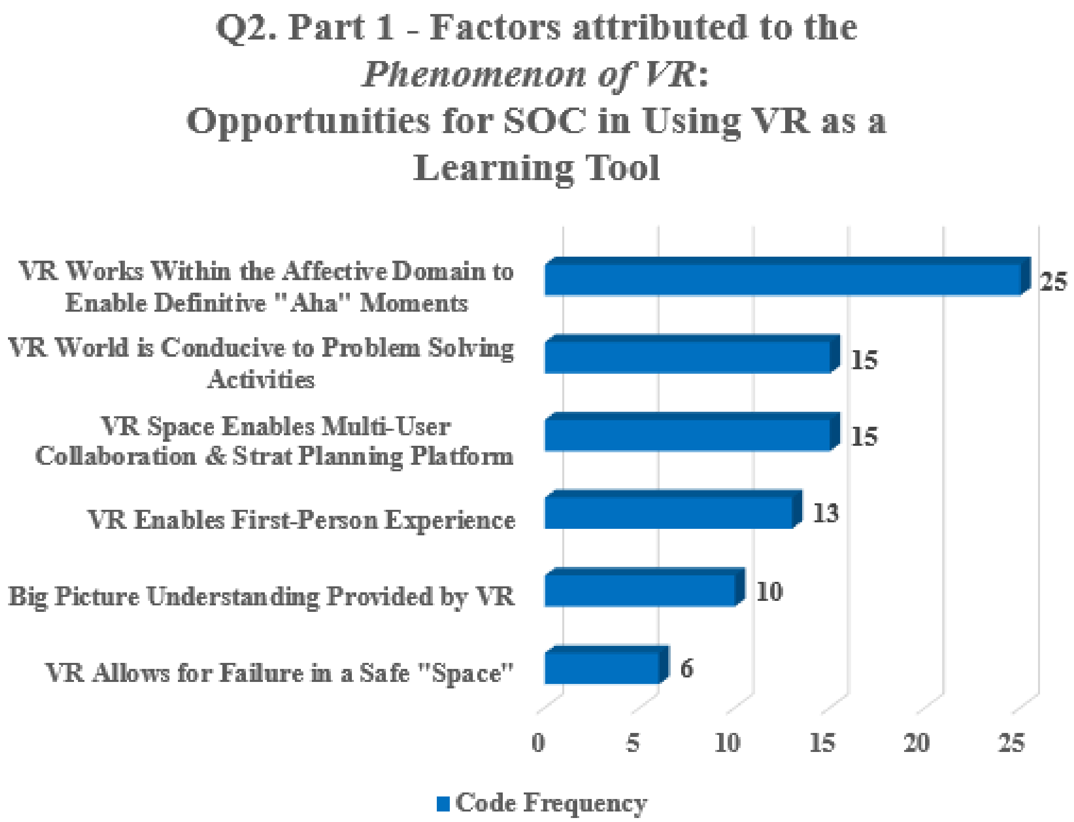

Figure 14. Factors Attributed to "The Phenomenon of VR"

As discussed substantially in chapter 2 literature review, the affective domain is an area where higher education, and Air Force PME in particular, can make great strides in improving the quality of learning. This was an area in which the research subjects provided one of the most strongly grounded inputs.

- The factor of "VR WORKS WITHIN THE AFFECTIVE DOMAIN TO ENABLE DEFINITIVE 'AHA' MOMENTS" was one in which many Stakeholders had strong opinions:
    - "It's an affective experience. That's what we're getting it for. So, you have to figure out, 'what do you want them to get out of this?' Are we trying to teach them certain principles (knowledge/comprehension-level stuff) OR do we want them to get a FEELIING out of it? (The AHA! Moment). So, we had a lot of discussions around

even that topic: how were we going to build this thing? We moved toward getting the experience; having the experience, the AHA! Moment, and we got pretty close to it, I think" (Stakeholder 29).

- "I can put them in a situation where it simulates true risk, or the stakes seem to be high, and when you do that you can engross them into an environment where, say, "A child is going to die! Oh, my God!" (Stakeholder 38).
- "We are getting to the point where technology is starting to get good enough to meet the students where they are – to reach that AFFECTIVE level. … When we took the helicopter ride, we all FELT it. Each person who's ever ridden in a helicopter felt that, and what it gave us was a glimpse into what the future CAN BE" (Stakeholder 32).
- "You know, they get this Affective in some of the TLPs (team leadership problems), the exercises they do – that's where they get that now. And some in the flight room maybe; I think a lot of them get it there. So, the challenge will be to identify what you want them to feel or to take out of here. It might be that it's about that AHA Moment. We have a 5-week course; I can imagine 5 experiences like this: one for each week" (Stakeholder 29).
- "We've talked about the SAPR (Sexual Assault Awareness) and I recently read this weekend that there are some products already out there that simulate scenarios to get you to feel what it's like to be sexually harassed. Those types of experience that actually put you in someone else's shoes – those are the kinds of experiences, that I think, would be most valuable to the students … You relate with that in such an emotional way, that all the sudden, your point of view changes. You can't put a price on that. There's no amount of training – to put someone through that to where they

come to their own conclusion. That's assigning self-worth to the learning (Stakeholder 31).

Additional factors identified in support of the theme "Factors Attributed to 'The Phenomenon of VR'" have been provided in ALL CAPS, followed by examples of the data that fit within each factor:

- "VR WORLD IS CONDUCIVE TO PROBLEM SOLVING ACTIVITIES"
  - "I think initially using VR for team problem solving events will help overcome the sentiment I mentioned. I believe students thirst for any type of team problem solving experiences we give them (Stakeholder 19).
  - "VR could be to throw students into a historical event or situation and allowing them to be in that world and come up with solutions to those problems and be able to actively play out those solutions in a virtual world and see the effects/results (Stakeholder 09).
  - "Maintainers can use this to see how to conduct heavy maintenance like an engine change. Depending on the Maintenance Data Sheet, this may not be a regularly occurring event but they will have seen it at least once in the virtual world. Can even incorporate unexpected damage to challenge their troubleshooting skills (Stakeholder 05).
  - "Students are continually giving me feedback that they greatly value Project X and other experiential problem solving events. I believe students will enthusiastically embrace VR application in this area (Stakeholder 19).
  - "In a virtual world, can you actually apply leadership, can you actually apply communication, can you apply problem solving in a synchronous environment where

people are in the virtual world (could be in several different locations,) but they're all in the virtual same place (Stakeholder 35).

- “We need to create the problem in the virtual world more in a real-life scenario where there's more vagueness to it and abstractness to it. Then we can probably see them apply other soft skills” (Stakeholder 35).

- “VR SPACE ENABLES A MULTI-USER COLLABORATION & STRATEGIC PLANNING PLATFORM”
    - “Multiplayer Virtual Project X offered initially as an elective and later as a requirement to support teambuilding, communication, and leadership” (Stakeholder 01).
    - “Integrate with ADWAR. Separate the JAOC director and deputy in another room and have them in a virtual AOC and see avatars of the teams (Goat, Dragon, etc.) and the entire Serengeti map. The other players will be in another room on computers executing their mission like normal but can only hear from their JAOC director via speakers since they will be geographically separated. This would strengthen how to come up with a communication plan for centralized Control, decentralized execution since the JAOC director cannot just walk over to another computer to point out targets” (Stakeholder 05).
    - “At a minimum, the multi-player project type applications should be developed. Even if they are optional for flights to reinforce team building concepts on their own time (i.e. the dorms)” (Stakeholder 25).
    - “I think a multiplayer project-X activity would show a lot of value, because you could have more possibilities and scenarios to try for new experiences. Also, it may make it easier to try new ways to do project-x type activities, such as dynamic team

reshuffling, doing events with more than 6-8 students, or even doing competitive TLPs with one group of students against another group. There are a lot of possibilities in VR that are not currently available in Project-X (such as the competitive team vs team idea)" (Stakeholder 26).

- "VR ENABLES FIRST-PERSON EXPERIENCE"
  - "It's more like….real life; it's like BEING there. So, it's a combination of all of them: you have the visual and the audio and all" (Stakeholder 29).
  - "What if you could actually move around in the space? What if you could interact? Those are the kinds of things where putting people into scenarios is the Kobayashi Maru in Star Trek. … eventually put people into scenarios, like in Holodeck, where they can honestly experience things that they would never be able to experience and have a level of EMPATHY for their commanders, for other folks, for what their airmen go through" (Stakeholder 32).
  - "There's kind of time pressured situations where you feel like you have to make a decision … because you've already been in virtual reality at that point for about 10 to 12 minutes. If you let yourself go, you're pretty-well immersed, at least mentally. A lot of people feel the pressure that they haven't felt about making a decision. Are they ready to make that decision? Do they have that ethical framework in their life to really make that decision? How do you build an ethical framework?" (Stakeholder 33).
- "BIG PICTURE UNDERSTANDING PROVIDED BY VR"
  - "VR can also enhance an Airman's understanding of WHAT the Air Force is – bring them to the ops floor (if support) and bring them to the operating room (if flyer) (etc.) and allow for cross-communication to occur through the force. You could do that as

part of the SOC curriculum to aid in the 'reblue-ing' of the students" (Stakeholder 01).

- "Create a scenario of decisions being made from various AFSC perspectives. For example, views from the cockpit of a F-15E talking to the JTAC and determining whether to bomb a target. This will help with giving a perspective to non-flyers out there. How about the same in an emergency room for medical personnel giving treatment to enemy combatants? A fast video that shows what is all required to generate a single aircraft" (Stakeholder 05).
- "VR can provide the visceral comprehensive story of what each service is doing simultaneously during a campaign. If you want us to learn more about Joint doctrine, put us in the cockpit, ship deck, boots on ground, & white house situation room - point of view … Conceptually VR is great for initial orientation where "showing" someone something to scale dramatically improves comprehension compared to simply reading limits or parameters" (Stakeholder 18).
- "Certainly training that is too costly to run and organize. This could help in large force training without requiring the whole force (Stakeholder 24).

* "VR ALLOWS FOR FAILURE IN A *SAFE SPACE*"
  - "Specifically, VR is an amazing resource for orienting and familiarizing trainees with technical systems & protocol prior to battlespace exposure. These platforms allow trainees to develop and solidify their cognitive and physical response measures to ensure their operational competency is more robust and resilient when the stress of combat is introduced" (Stakeholder 23).
  - "VR can allow for a "failure" and robust feedback (such as recording performance for students to view post-event and reflect on their performance)" (Stakeholder 01).

- "It's more safe, it's more repetitive, it's lessons learned. Because in the real world you're trying to do those things it becomes costly, it's more dangerous, you can't repeat it, quickly. In the Virtual world, I can change the scenario pretty quickly if I want to" (Stakeholder 35).

Theme 2.2 – Factors attributed to use cases for VR: opportunities. Within the research question 2, "Opportunities for SOC in Using VR as a Learning Tool," the second main theme was "Factors Attributed to *'Use Cases for VR'*." The defining criteria for data codes to be assigned to factors within this theme was that there were multiple specific ways that SOC Stakeholders envisioned VR to be used; these "use cases" all come together to comprise a well-grounded theme of opportunities.

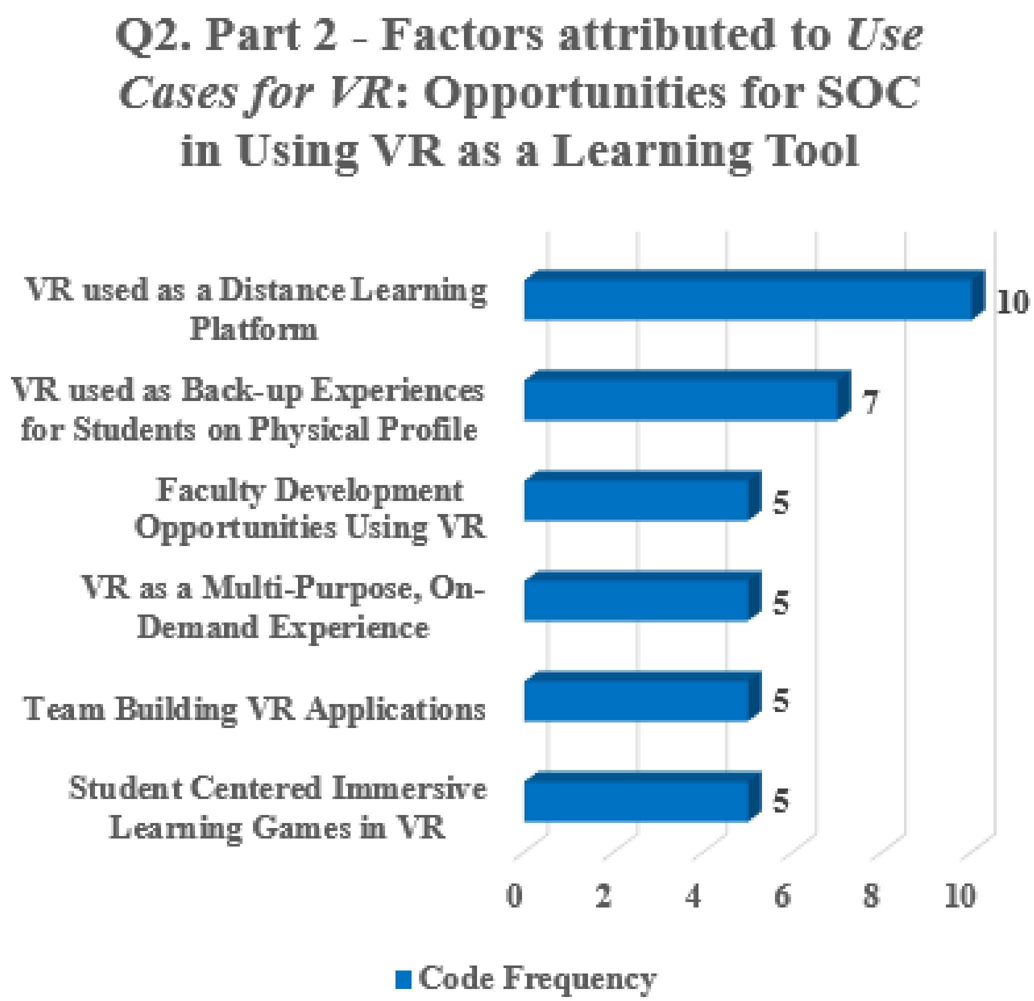

Figure 15. Factors Attributed to "Use Cases for VR" – Opportunities for VR in Learning

- The strongest use case for VR articulated by SOC Stakeholders as an Opportunity was the case in support of the factor, "VR USED AS A DISTANCE LEARNING PLATFORM"
  - "I do see it greatly benefiting students who are taking SOS or ACSC online. This is where VR can really have a positive influence for the students. This is where experiential learning events can be placed (Stakeholder 03).
  - "If we have the opportunity to let the eSchool have something like an ADWAR then that would be a tremendous success over the current version" (Stakeholder 36).

- “VR should be used in circumstances that we place students in positions that aren’t possible in a residence course. That could mean use in distance learning, or by creating scenarios or training that induces something that isn’t possible in the physical world (i.e. creates stressors, evokes emotions, or overcomes resource or physical constraints” (Stakeholder 06).
- “A lot of participants I saw go through it, their thoughts on this were, ‘this is very, very useful.’ They say in the distance learning courses, because it gets away from the asynchronous environment. The big thing is if you start getting into concepts other than leadership, you get into war fighting, doctrine, application of theory, and interactional relations” (Stakeholder 35).

Additional codes used in the theme “Factors Attributed to ‘Use Cases for VR’ – Opportunities for VR in Learning” have been provided in ALL CAPS, followed by examples of the data that fit within each factor:

- “VR USED AS BACK-UP EXPERIENCES DURING INCLEMENT WEATHER AND FOR STUDENTS ON PHYSICAL PROFILE”
  - “We should have VR backups to physical experientials. These should be used for DL students and in-residence students that are injured or on a profile restricting physical activity” (Stakeholder 08).
  - “And I think when you can give experiences: probably the best example that I’ve pushed for here is that we tend to have about 3-5% of our students hurt. So, by the end of the class, but so much- over 40% of our curriculum is outside, interactive, doing Team Leadership Problems, things that involve physical stress, mental stress, fatigue, all of those kind of things. So, replicating that in a virtual world is a GOAL because there’s a NEED” (Stakeholder 32).

- “For me it's more of a backup than it would be a primary. We get a lot of students that break while they're here, and then they can't participate. And my peers here, half their time is telling people, "No, you're broken. Come back later. Come back later" And we get a lot of push-back… But the thing is, if you send a broken ... as our current construct, a broken student will sand-bag their flight. You're hurting your other 13, by not being able to run, or being able to participate in physical activities. VR would be a good option if they break” (Stakeholder 37).
- “We have a lot of people come here that break their ankle. In one class we had like 12, who showed up who shouldn't have been sent here because they didn't pass their PT test or they were pregnant. They can’t be running in the heat in Alabama five months pregnant, six months pregnant. Holy cow! So we send them home: look at all the money that's wasted. Rather than do that, have them participate in a Virtual Team Leadership Problem or a Virtual Project X. We have already done this” (Stakeholder 10).

• “FACULTY DEVLOPMENT OPPORTUNITIES USING VR”

- “I think it could be used from a Faculty Development perspective to help us work on debriefing. For example, if the students in the instructor course could watch a recorded experiential application from the virtual world, or one that we purposefully create to force certain debrief points, we could more effectively train them on debriefing without actual students present. This would give us more flexibility for how we train them on debriefing and reach those who learn a different way” (Stakeholder 02).
- “Could create something for Teaching Principles in Adult Education (TPAE), say, classroom management problems; practice teaching venues, etc. (Stakeholder 07).

- “VR AS A MULTI-PURPOSE ON-DEMAND EXPERIENCE”
    - “Start offering “lunch time electives” that allow people to experience VR as soon as possible…ask the students how they would use this tool…then give them feedback on if/when their suggestions are incorporated” (Stakeholder 01).
    - “I think students would be best served if some apps were developed that could be downloaded/installed on students’ smart devices (phones & iPads) that could be used in class as attention steps and learning activities” (Stakeholder 16).
    - “Team Leadership Problems for weather contingencies - Pre-recorded applications to replace auditorium lectures - Virtual Air Park tour when raining/lightning - Wargaming for ‘flight vs. flight’ combat … Incentives for quarterly/yearly awards (instead of trophies & coins)” (Stakeholder 21).
- “TEAM BUILDING VR APPLICATIONS”
    - “The multi-player project type applications should be developed. Even if they are optional for flights to reinforce team building concepts on their own time (i.e. the dorms)” (Stakeholder 25).
    - “I think that having multiple problem solving events that force team building, communication, followership, and leadership… Create a scenario of decisions being made from various AFSC perspectives” (Stakeholder 05).
    - “All activities need to remain focused on flight development (team building, SWOT analysis, problem solving, etc). If they are not, then the students will wonder why they are here vs distance learning” (Stakeholder 25).
- “STUDENT-CENTERED IMMERSIVE LEARNING GAMES IN VR”
    - “It’s focused around student-centered learning. You're allowing them to pick a pathway that they learn best. VR is just another one of those tools as part of that

student-centered learning through a simplified method where they all meet at one place. They can exchange all those ideas. As they go different pathways, it's going to give people different perspectives. They can think more critically about things in different ways" (Stakeholder 33).

- "We should have VR worlds available that gamify the most technical lessons that we teach at SOS (JFO, NCS System). These would work much like the VAOC to help students connect to highly technical and complex topics" (Stakeholder 08).
- "Everybody doesn't have to have the SAME experience. One of the things we've looked at is, 'can we make this where we have a suite of tools that's where, - you know best what you need.' And you know the best way for you to grow." So, if you think that you haven't had any real leadership experience, you haven't had an opportunity to really work with airmen or anything else, here's a suite that's off-the-shelf, and here's a lab that you can go to" (Stakeholder 32).
- "Adult learners learn when they want to learn. It may be a class. It may be when they're sitting at home reading an article and it makes them think of something or listen to some music that makes them be introspective about a certain topic. You never know when somebody is going to turn on their learning brain, if you will. It's called student-centered learning. Riding on a wave of living knowledge" (Stakeholder 33).

Theme 2.3 - Factors attributed to unique stakeholder groups: opportunities. The third theme, "Factors Attributed to *Unique Stakeholder Groups"* are factors that relate to the point that a wide variety of stakeholders are involved in the SOC learning environment – both internal and external. The participants' inputs within this section demonstrate that since each of these stakeholder groups sees VR from a different perspective, SOC can keep focus on the opportunity to enable positive change in the future.

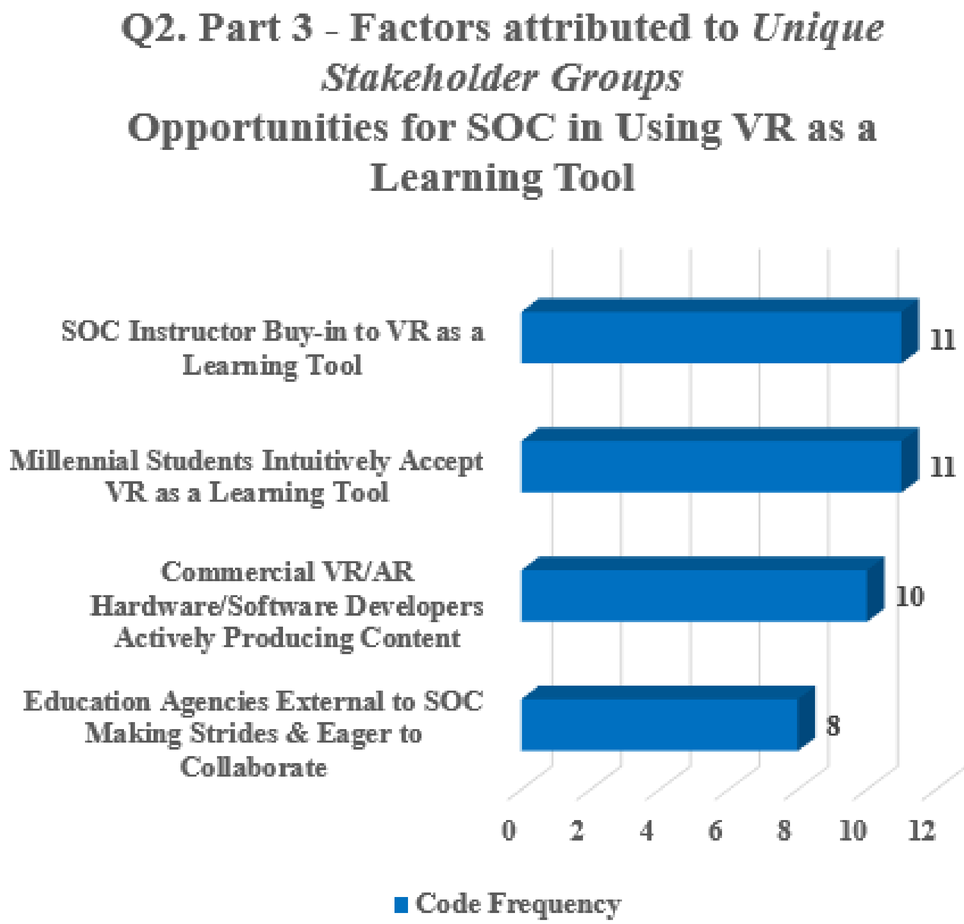

Figure 16. Factors Attributed to "Unique Stakeholder Groups" – Opportunities

- "SOC INSTRUCTOR BUY-IN TO VR AS A LEARNING TOOL" was indicated as a strongly grounded factor in this part of the Opportunities question. Instructors are critical stakeholders for any learning venture in any educational setting.
  - "Getting instructors involved with the learning, facilitating/leading/evaluating/acting as referee. That role may be more complicated to program and execute in the virtual space with current technology conditions/restrictions" (Stakeholder 04).
  - "Instructor buy-in. If instructors fully support this initiative, then students will buy-in too. I think this has to be the pivotal first step before students even see it (Stakeholder 05).

- "Building a corps of experienced and knowledgeable faculty to fully utilize the resource is crucial (Stakeholder 06).

Additional factors identified in the theme "Factors Attributed to 'Unique Stakeholder Groups'" are provided in ALL CAPS, followed by examples of the data that fit within the given factor:

- "MILLENIAL STUDENTS INTUITIVELY ACCEPT VR AS A LEARNING TOOL"
  - "This generation is entirely raised on technology. They were raised on tablets, they were raised on communicating, virtual headsets. It's a different world. Their gaming experience, even, is different. So if this is introduced, it's second nature to them" (Stakeholder 36).
  - "VR is a native environment to most members of the 18-25 year old demographic in the US and so is ideal as strategic messaging vehicle for any company or government organization looking to enhance its recruiting efforts" (Stakeholder 23).
  - "If we want to try and get ahead of this, where are students going to be in 3-5years? So you're looking at the 22-year olds right now and what is their connection to technology? Obviously it's extraordinary…. especially in comparison to us – (the digital natives type thing.) So our thing was to look at technology as a leverage point" (Stakeholder 32).
  - "I was shocked we get in there and I'm like, "Hey guys, we're trying to figure out the technical difficulties." These guys were doing the hard part for me. If I'd used those with lieutenant colonels or another group other than millennials and this type of age group I think it would have been a lot harder for us to actually execute. It was quite surprising how much more they knew about the stuff that I was trying to go through and show and have them go through it" (Stakeholder 35).

- "It's exciting and the younger generation that's coming up; these are younger captains they live in a different world than the forty-something's, fifty-something's, 60-somethings, so we have to be able to speak a language that will be conducive to learning for them" (Stakeholder 36).

- "COMMERCIAL VR/AR HARDWARE/SOFTWARE DEVELOPERS ACTIVELY PRODUCING CONTENT"
  - "And those opportunities with open-source products – all those challenges are starting to flatten-out, and the stars have aligned" (Stakeholder 30).
  - "And the HoloLens especially because it's literally a Windows 10 computer that sits on your face and it's networked. So the other ones, the HTC Vive and the Oculus, those two are more peripherals, but the HoloLens is an actual computer. You're talking about enterprise applications. The need to collaborate with other like-minded people is there even more so" (Stakeholder 31).
  - "They already have things like spacial-oriented sound, so if I turn my head over here and someone in the simulation is shouting from like simulated 20 feet away, it sounds like they're 20 feet away. You combine all these different technologies together and it will only get better. This device does this good; the Oculus has the better display by a little bit. The HTC Vive has the better tracking for the controllers. There's another VR application that does eye tracking inside of the display, so that wherever I look at, it puts that section of the screen in focus, which is also another technology that's really good" (Stakeholder 31).
  - "Eventually we'll get to that point of just like we did with the personal computer, just like we did with the smartphone; it will be commonplace" (Stakeholder 31).

- “EDUCATION AGENCIES EXTERNAL TO SOC MAKING STRIDES & EAGER TO COLLABORATE”
  - “Working with folks at MIT, Stanford, Harvard, Columbia; they have been just wonderful. Just because they are on the civilian side, and we’re on the academic military side, it’s still higher education, and they have the same challenges. Their stars align quicker in some cases; some of them are still waiting for it. We’ve been very fortunate. … For us, it was all about enhancing learning. With them, it’s the same thing; so we all have the same goals in mind. How we get there – our paths may be a little bit different” (Stakeholder 30).
  - “The Breakout franchise (coming to Montgomery soon) has professional rooms set up that could easily be adapted to the VR world and even more variables added since we are not constrained by the physical environment” (Stakeholder 05).
  - “Things you cannot get face-to-face here in person. For example, instead of theorizing about process improvement or workplace efficiency/morale, you could work with a company that does those things well to create a virtual space in which students can take a virtual ‘field trip’ to see firsthand how others make their environment the best (e.g. Google/Apple/etc.)” (Stakeholder 22).
  - “We've got the VR second life environment and cooperating with quite a few universities. Columbia, Harvard, MIT, Stanford, … who collaborate. They're very excited about us using this in our curriculum” (Stakeholder 38).
  - “We could have the students interacting with other schools. Right now we do combined ops with the senior NCO academy over at Gunter. We could do that virtually. We could do that virtually with the Kisling NCO academy in Germany.

ALS. We could talk with the marines in Quantico or the FBI in Quantico" (Stakeholder 38).

Theme 2.4 –Air Force-wide (not just at SOC) opportunities. The fourth part of the Opportunities question included "Factors Attributed to *Uses Applicable Air Force-Wide*. This theme was based around the idea that there are certain opportunities that are applicable not just within the SOC learning environment, but Air Force-wide. Since the main focus of the present research was toward SOC versus an Air Force-wide perspective, this was a very limited list. However, because the participants' inputs that related to opportunities outside of SOC were captured, the chance to offer-up this data as a starting point for a possible future study was a valuable research reporting opportunity.

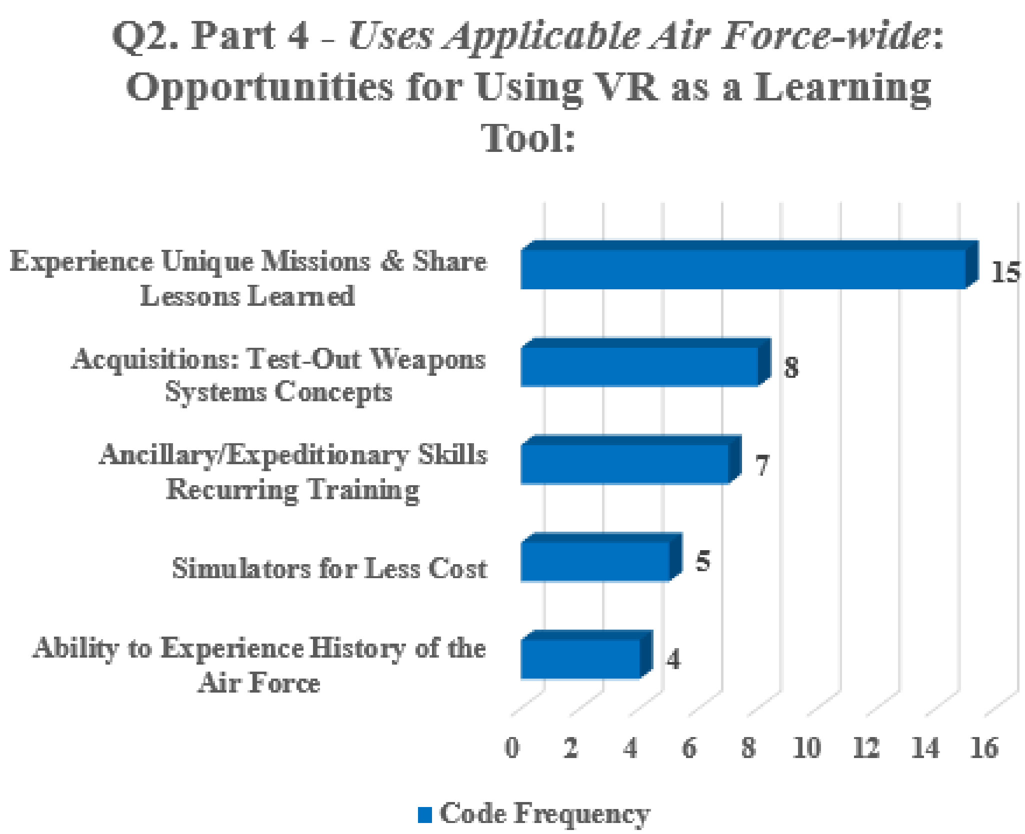

Figure 17. Uses Applicable Air Force-wide – Opportunities

Experiential Learning theory was discussed substantially in chapter 2. This question demonstrates how SOC Stakeholders see ELT being very important to the application of VR in the learning environment.

- For the first, strongest-grounded result in this part of the question SOC Stakeholders identified: "EXPERIENCE UNIQUE MISSIONS & SHARE LESSONS LEARNED"
  - "Combined with better VR systems and physical interaction (i.e. augmented reality with virtual environments) could aid in mission rehearsal, specialized training (drop zone or assault zone control officers), parachute training, etc." (Stakeholder 06).
  - "One area that comes to mind are ground mission qualifications for aircrew. It currently takes several days to train a drop zone control officer or landing zone safety officer. This could be potentially cut down by employing VR for the practicum" (Stakeholder 08).
  - "VR can provide the visceral comprehensive story of what each service is doing simultaneously during a campaign. If you want us to learn more about Joint doctrine, put us in the cockpit, ship deck, boots on ground, & white house situation room - point of view, site surveys for ADVON (advance echelon) teams. If you wanted to get really brave, you could mirror the Installation Readiness Plan like Grand Theft Auto did for Miami City" (Stakeholder 18).
  - "They want to get in there and roll their sleeves up and be a part of it, and if you give them an opportunity, you will not have a nodding head in that room. They want to get so involved, we've seen where even after they graduate, they want to be a part of what this means in the future (Stakeholder 30).
  - "I've fought many enemy on the battlefield and we can have the best capability and the best trained men and with the most awesome weapons, but if you don't use them

in the timely manner and the enemy gets you by surprise, or they actually can neutralize that by putting you on the defensive, the game is over. Putting people in a virtual area like that where they have to make decisions that have to be timely, and have to learn how to coordinate and work together, and really understand how." (Stakeholder 33).

Additional factors used in the theme "Uses Applicable Air Force-wide: Opportunities for using VR in Learning" have been provided in ALL CAPS, followed by examples of the data that fit within the given factor:

- "ANCILLARY/EXPEDITIONARY SKILLS RECURRING TRAINING"
  - "Imagine we get read of ADLS completely. We don't do anything like the fire extinguisher training anymore; instead, we have an app on our phone. (We don't even need to issue you a phone because everybody has one.) The Air Force training app gives you a notification on your phone – let me slip it into my Google Cardboard and do that right quick" (Stakeholder 31).
  - "Chemical Warfare Defense Equipment, Self-Aid Buddy Care (first aid), convoy ops & other ancillary and pre-deployment training" (Stakeholder 10).
  - "Ancillary training" (Stakeholder 12).
  - "Pre-deployment training, possibly medical trauma training, death notification training, field training for services or any career field who has to set up "bare bases," security forces training, etc." (Stakeholder 14).
  - "Overhaul annual training (ADLS) activities that use legacy technology & graphics 16

- "there are some ancillary training modules (CBTs) that could lend towards VR applications (Cultural Familiarization, CBRN-E, Self-Aid & Buddy Care)" (Stakeholder 20).

- "SIMULATORS FOR LESS COST"
    - "Cheaper version of simulator. Will allow you to experience missions/lessons learned" (Stakeholder 15).
    - "I think VR would be very useful for mobility pilots for airfield study, airspace study, and route, (especially low level) rehearsal. Instead of "chair flying" 2D charts, aircrew can really experience the environment they will be flying in much as we do in the simulator, but without the simulator operating costs" (Stakeholder 19).
    - "Would enhance the Space Standard Trainer for Space officer training (spacelift, satellite operations, etc)" (Stakeholder 21).
    - "The flying world has been using this kind of tech for years in simulators, and should continue to do so as the tech evolves. In the future, it'd be nice if training bases could issue students VR headsets & controls to practice simulator flying prior to jumping in the big simulators" (Stakeholder 22).
- "ACQUISITIONS: TEST-OUT WEAPONS SYSTEM CONCEPTS"
    - "For acquisitions, to test out weapon system concepts prior to final design/implementation decisions" (Stakeholder 13).
    - "Space and Cyber systems acquisition, during Request for Proposal (RFP) development. When acquiring complex systems from industry, it's a common practice for the Government to design a fictitious mission scenario to give potential offerors an understanding of the Government's concept and a use case to build a proposal around. I think a VR environment would be much more effective than a

written description (commonly used now) because there is so much more that can be communicated through an interactive virtual display of the Government's mission concept or scenario. This would help both the Government program office and the industry partners to see and understand the same thing and result in higher quality RFP and contractor proposals. This idea could also be applied during pre-solicitation activities, such as Industry Days, Requests for Information (RFIs), Broad Area Announcements (BAAs), Task Orders on research or study contracts, such as Indefinite Delivery/Indefinite Quantity (IDIQ) or calls for Small Business Innovative Research (SBIR) contracts" (Stakeholder 26).

- "VR may help Government acquisition activities is during Concept Development or Development Planning. Many acquisition centers, such as the Space and Missile Systems Center (SMC) at Los Angeles Air Force Base have a Directorate of Development Planning (SMC/XR). This office is typically tasked to conduct long-term planning activities, usually 10-20 years in the future, to develop the weapon system concepts and technology roadmaps that would be required to meet potential capability needs. VR could enable a much higher fidelity method to create and visualize these new weapon system concepts and their components (Stakeholder 26).

- "ABILITY TO EXPERIENCE HISTORY OF THE AIR FORCE"
    - "Think about teaching air power history. Then you go zoom yourself into a World War II bomber or something like that could be very useful" (Stakeholder 33).
    - "use VR (i.e. metaverse) as an area on a website like www.af.mil to educate members on The history of The AF and have an area where individuals can watch senior leader presentations. 03

- “Virtual Museum of Air Force History & Doctrine (Aircraft, Wars/Battles, People, Cyber, Space)” (Stakeholder 10).
- “I could put this thing on my head, (a student) in an empty auditorium, and there, I see a presenter and I see a Medal of Honor recipient. And I’m watching the citation happening in front of my eyes. That’s going to be a test question on PME” (Stakeholder 31).

Question 3 – Current/Future VR Applications with impact on SOC learning

Beyond just looking to challenges, strategies to address the challenges, and opportunities, the pragmatic focus of this research study endeavored to synthesize a compendium of specific applications for VR as an output of question 3. Within this research question, there were four main parts:

1. *Status Quo* VR Apps: Substitute or Supplement Existing SOC Programs or Lessons
2. *In Extremīs* VR Apps: Death or Extreme Danger would be Evident if Done Live
3. *In Sitū Impedientī* VR Apps: An Impediment Inherent to the Situation prohibits Live
4. *Opibus Humanīs* VR Apps: Practical VR Learning Apps Relating to People Processes

Theme 3.1 – *Status quo* VR apps: sub or supplement existing programs. With every new generation of technology, the first applications for the technology typically begin with doing the same activities that have always been done but trying to do those things better. This particular part of question 3 was developed with this concept in mind: *Status Quo* (i.e. doing what we already know how to do, but perhaps doing it better or more efficiently/effectively)

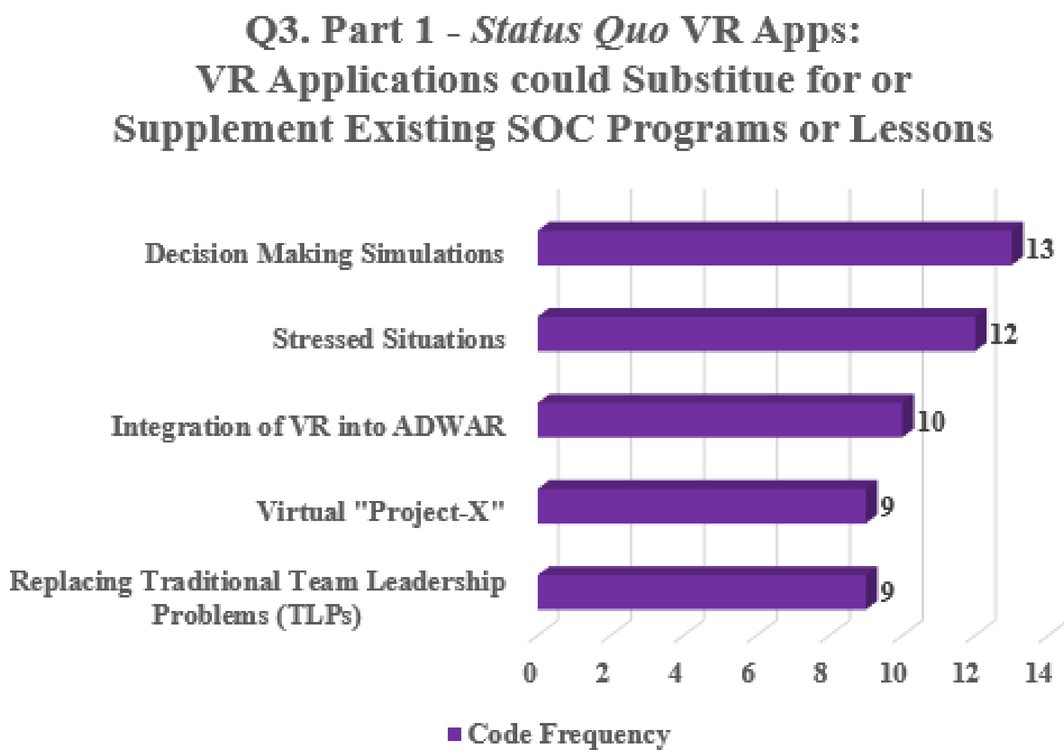

Figure 18. Status Quo VR Apps: Sub for or Supplement Existing SOC Programs

- SOC has historically employed "DECISION MAKING SIMULATIONS" as an educational tool (such as "the Commander's Inbox Exercise in which students simulate the routine daily decisions made by a commander). The data in this code pointed toward the idea of using VR in this arena:
  - "A decision-based feedback session could be developed that allows students to conduct a virtual feedback session and apply various FRLM behaviors based on what the virtual subordinate displays" (Stakeholder 16).
  - "In a virtual world, you can give people those chances to make decisions and understand what risk needs to be accepted at what levels and start to really train people. I mean, you can use it for training, not just education and help them understand what decision is mine to make and what decision is my boss's to make.

That's called experience. If I can give people experience through training, then we're going to be that much better at war fighting" (Stakeholder 33).

- "if you go back to the feedback and some discussions we had with some students: some of them had "AHA! Moments" where they were like, "WOW, I had to make a decision pretty fast. I was in there engrossed in it and I need to think about my leadership before I get into these situations" (Stakeholder 29).
- "If you let yourself go, you're pretty well immersed, at least mentally. A lot of people feel the pressure that they haven't felt about making a decision. Are they ready to make that decision? Do they have that ethical framework in their life to really make that decision?" (Stakeholder 33).

Additional factors used in the theme "*Status Quo* VR Apps: Substitute for or Supplement Existing SOC Programs/Lessons" have been provided in ALL CAPS, followed by examples of the data that fit within the given factor:

- "STRESSED SITUATIONS"
  - "In particular VR could potentially be used to place the students in a stressed situation such as an ethical dilemma (you must choose to leave one person behind, or your mission has been compromised and you must select a path that has possible negative connotations). VR can allow for a "failure" and robust feedback (such as recording performance for students to view post-event and reflect on their performance)" (Stakeholder 01).
  - "I've heard of a promising idea to develop a VR cinematic feature to depict various outcomes to ethical decisions. Specifically, the idea involved overlaying the Son Tay Raid scenario (formerly from the SOS Ethical Warrior lesson) into four distinct VR cinematic vignettes that illustrate the outcome of each flight lead's decision to either

support or object to the mission plan. We could allow small groups of students to participate in the VR simulation as the second part of three-part modulated lesson plan (first part: student prep, second part: VR sim, third part: classroom discussion) (Stakeholder 23).

- "The second part is the leadership piece. As you walk through the scenario, depending on how you led one of the troubled soldiers, he's going to react differently. That can show you that leading your people in the right way, or an effective way, can really be detrimental or helpful in the battlefield. If somebody's turned on and they're paying attention, they can be a huge asset. If they're not, you might be carrying body bags home. That's a really regretful thing to do. There's that piece" (Stakeholder 33).
- "All the money in the world. I would have 45 sets of these things on carts that roll into every single flight room and when they did the next exercise everybody's virtual and I can make 600 captains in Iraq together, in a way that they could never do that. The learning possibilities for every aspect of our curriculum could be hit but there are things that you wouldn't replace (Stakeholder 38).

• "INTEGRATION OF VR INTO ADWAR"

- "Integrate with ADWAR. Separate the JAOC director and deputy in another room and have them in a virtual AOC and see avatars of the teams (Goat, Dragon, etc.) and the entire Serengeti map. The other players will be in another room on computers executing their mission like normal but can only hear from their JAOC director via speakers since they will be geographically separated. This would strengthen how to come up with a communication plan for centralized Control, decentralized execution since the JAOC director cannot just walk over to another computer to point out targets" (Stakeholder 05).

- "Multi-phased scenario to tie in all Warfare and International Security Studies, culminating in an Air Campaign such as ADWAR" (Stakeholder 10).
- "I also think that VR could be used to create an additional Warfare Curriculum Capstone to replace FLEX Op" (Stakeholder 20).
- "Wargaming for flight-versus-flight combat" (Stakeholder 21).
- "If you can make me work mentally at a problem, this can really be a powerful tool. This is where we can start to think about how we're going to control domains and how we're going to fly in a multi-domain world because what I would like to see happen at some point, I'd like to see my 14 captains, instead of playing ADWAR, put a VR situation on" (Stakeholder 33).

- "VIRTUAL 'PROJECT-X'"
  - "I think a multiplayer Project-X activity would show a lot of value, because you could have more possibilities and scenarios to try for new experiences. Also, it may make it easier to try new ways to do project-x type activities, such as dynamic team reshuffling, doing events with more than 6-8 students, or even doing competitive TLPs with one group of students against another group. There are a lot of possibilities in VR that are not currently available in Project-X (such as the competitive team vs team idea) (Stakeholder 26).
  - "Not only can there be formal flight events equivalent to Project X. I believe there is great value in offering optional VR-based problem solving events where flights can hone their problem solving and build up their team on their own time (Stakeholder 19).
  - "There's twenty something tasks that you can do with outdoor project X. We developed a couple of them in the virtual world ... They came from project X, but

they're called tasks. When those were developed in the virtual world, it was challenging. Because it was a task the students used more of a transactional behavior. I found if you built a more abstract problem in the virtual world then the students have more options to use more of their soft skills than just transactional" (Stakeholder 35).

- "REPLACING TRADITIONAL TEAM LEADERSHIP PROBLEMS (TLP'S)"
  - "At this point VR events seem like a good supplement to traditional SOS events; I'm looking forward to the point where it can used to replace traditional TLPs, but understand that this may be a long time from implementation" (Stakeholder 17).
  - ""I believe there is most value in VR application to experiential team problem solving events … students thirst for any type of team problem solving experiences we give them" (Stakeholder 19).
  - "At a minimum, the multi-player project type applications should be developed. Even if they are optional for flights to reinforce team building concepts on their own time" (Stakeholder 25).

Theme 3.2 – In Extremīs VR Apps: death/extreme danger evident with live. Colonel Thomas Kolditz, PhD, in the seminal book, *In Extremīs* Leadership, describes the term *In Extremīs* leadership as:

> "… giving purpose, motivation, and direction to people when there is imminent physical danger and where followers believe that leader behavior will influence their physical well-being or survival. In extremis leadership is not a leadership theory. It is an approach that views leader and follower behaviors under a specific set of circumstances-contexts where outcomes mean more than mere success or failure, pride, or

embarrassment. Outcomes in in extremis settings are instead characterized in terms of hurt or healthy, dead or alive."

Kolditz, while professor at the U.S. Military Academy at West Point, conducted the breakthrough research in which he and his research team interviewed dozens of people whose occupation or vocation puts them into situations that are life-and-death on a regular basis. The findings from his research became the premise behind the *In Extremīs* leadership approach. *In Extremīs* leadership is a subject that has been integrated into the curriculum within multiple PME programs. Incidentally, the participants in the present research identified *In Extremīs* situations as an important set of scenarios in which VR could add value to the PME leadership learning environment. As such, this report introduced the idea of *In Extremīs* VR Applications as a primary class of applications for VR in education.

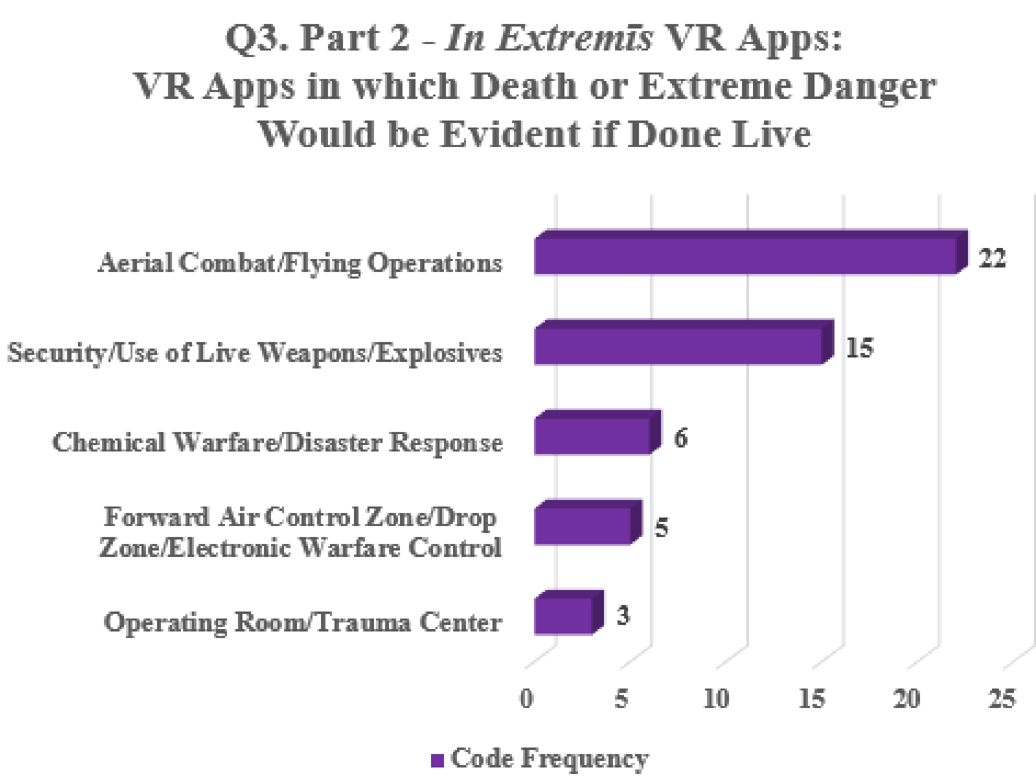

Figure 19. In Extremīs VR Apps: Death or Extreme Danger Evident if Done Live

- True to their colors, the US Air Force Squadron Officer College Stakeholders identified the idea of conducting “AERIAL COMBAT/FLYING OPERATIONS” in virtual reality as the most strongly grounded component of *In Extremīs* applications of VR.
  - “VR systems and physical interaction (i.e. augmented reality with virtual environments) could aid in mission rehearsal, specialized training (drop zone or assault zone control officers), parachute training, etc.” (Stakeholder 06).
  - “One area that comes to mind are ground mission qualifications for aircrew. It currently takes several days to train a drop zone control officer or landing zone safety officer. This could be potentially cut down by employing VR for the practicum” (Stakeholder 08).
  - “I think VR would be very useful for mobility pilots for airfield study, airspace study, and route, (especially low level) rehearsal. Instead of “chair flying” 2D charts, aircrew can really experience the environment they will be flying in much as we do in the simulator, but without the simulator operating costs” (Stakeholder 19).
  - “I think a live fly air campaign could be very useful. If we couldn’t get to a full air campaign, it would be very helpful to have vignettes such as CAS that included sample communications between the JTAC and strike asset(s). This type of scenario could be provided by our students. This will likely focus on current ops, but we should also include examples from major theater war” (Stakeholder 27).

Additional factors used in the theme “*In Extremīs* VR Apps: Death or Extreme Danger Evident if Done Live” have been provided in ALL CAPS, followed by examples of the data that fit within the given factor:

- "SECURITY/USE OF LIVE WEAPONS/EXPLOSIVES"
  - "OSI could use it to practice interviewing, clearing a house, testifying in a court martial etc- all of the things that we don't have opportunities outside of the formal schoolhouse to practice until we are actually doing them as live operations. It could even be used as a supplement at the OSI schoolhouse" (Stakeholder 02).
  - "Time travel/shifting, putting someone into the cockpit or gun turret of an aircraft under fire, or visualizing the cyber domain or its effects" (Stakeholder 06).
  - "Training scenarios that would otherwise be too costly, hazardous, etc." (Stakeholder 13).
  - "Possibly medical trauma training, death notification training, field training for services or any career field who has to set up "bare bases," security forces training, etc." (Stakeholder 14).
  - "They're usually drawn back into, oh I should have paid attention because 16 people in my airplane just got blown up because the guy had an IED in his pouch" (Stakeholder 33).
- "CHEMICAL WARFARE/DISASTER RESPONSE"
  - "Allowing to place people in a situation to 'rehearse' a response and gain feedback (such as an on-scene commander's course attendee responding to an oil spill, or natural disaster)" (Stakeholder 01)
  - "There are some ancillary training modules (CBTs) that could lend towards VR applications (Cultural Familiarization, CBRN-E, Self-Aid & Buddy Care)" (Stakeholder 20).
  - "I put this chem suit on, I'd never deployed before I didn't understand what this all meant. I wasn't able to connect the dots. People would explain it to me, it didn't make

sense. It made sense once I actually deployed two years later as a captain and come home to my base and I was like, ‘Now it makes since why we do an exercise and have to wear MOPP gear’” (Stakeholder 35).

- “Well it's very expensive to provide an experience to somebody as compared to training you and making you go through and put on the chemical gear, make you walk through it, and then say, ‘that's just training.’ That doesn't give the experience where you can connect the dots. But using immersive environments and virtual environments you can create an experience that's inexpensive. You can change it over. It's safe; you can do it repetitively” (Stakeholder 07).
- “A need where simulating something would be too dangerous for people. And I saw some on your list on there. I agreed with all that. But the same thing, like thrown in a room with teargas, you really can't do that virtually” (Stakeholder 09).

- “FORWARD AIR CONTROL ZONE/DROP ZONE/ELECTRONIC WARFARE CONTROL”
    - “Mission rehearsal, specialized training (drop zone or assault zone control officers), parachute training, etc.” (Stakeholder 06).
    - “Ground mission qualifications for aircrew. It currently takes several days to train a drop zone control officer or landing zone safety officer. This could be potentially cut down by employing VR for the practicum (Stakeholder 08).
    - “Vignettes explaining interdiction, strike, air engagements (forward-hemisphere, rear hemisphere, abeam) to give an example of very simple air-to-air combat. Vignettes that show how jamming/electronic attack effects an enemy’s weapon systems or IADS, terrain masking and stealth technology. Air space control could also be depicted among many other things” (Stakeholder 27).

- "For intel, using VR or 3-D modeling for integrated air defense system structure (IADS), radar and SAM coverage would be helpful for mission planning. This would be especially true if you could program terrain masking and the effects of electronic warfare such as jamming or stealth/low-observable technology on the enemy's IADS. This would also be very helpful for special ops forces especially if you could include light source/shadow data, drainage or water, etc." (Stakeholder 27).

- "OPERATING ROOM/TRAUMA CENTER"
  - "Bring them to the operating room (if flyer) (etc.) and allow for cross-communication to occur through the force" (Stakeholder 01).
  - "In an emergency room for medical personnel giving treatment to enemy combatants" (Stakeholder 05).
  - "Medical trauma training, death notification training, field training for services or any career field who has to set up "bare bases," security forces training, etc." (Stakeholder 14)

Theme 3.3 – In Sitū Impedientī VR apps: situational impediment prohibits live. Beyond the class of applications in which a person's life would be in peril if experienced "live," the second class of VR experiences that were identified by SOC Stakeholders was characterized by the researcher as *In Sitū Impedientī* VR Applications. The Latin phrase roughly translates to: "the situation impedes," or, in other words, something inherent to the situation makes it unlikely that this situation could be experienced live. Such inherent impediments include: "turning back the clock." Given currently known laws of time and space, the idea of turning back the clock for a first-person experience in history is not possible in real life. Likewise, situations impede real life experiences in terms of resource constraints, travel constraints, or human physical condition constraints (particularly in the case of those who are disabled.)

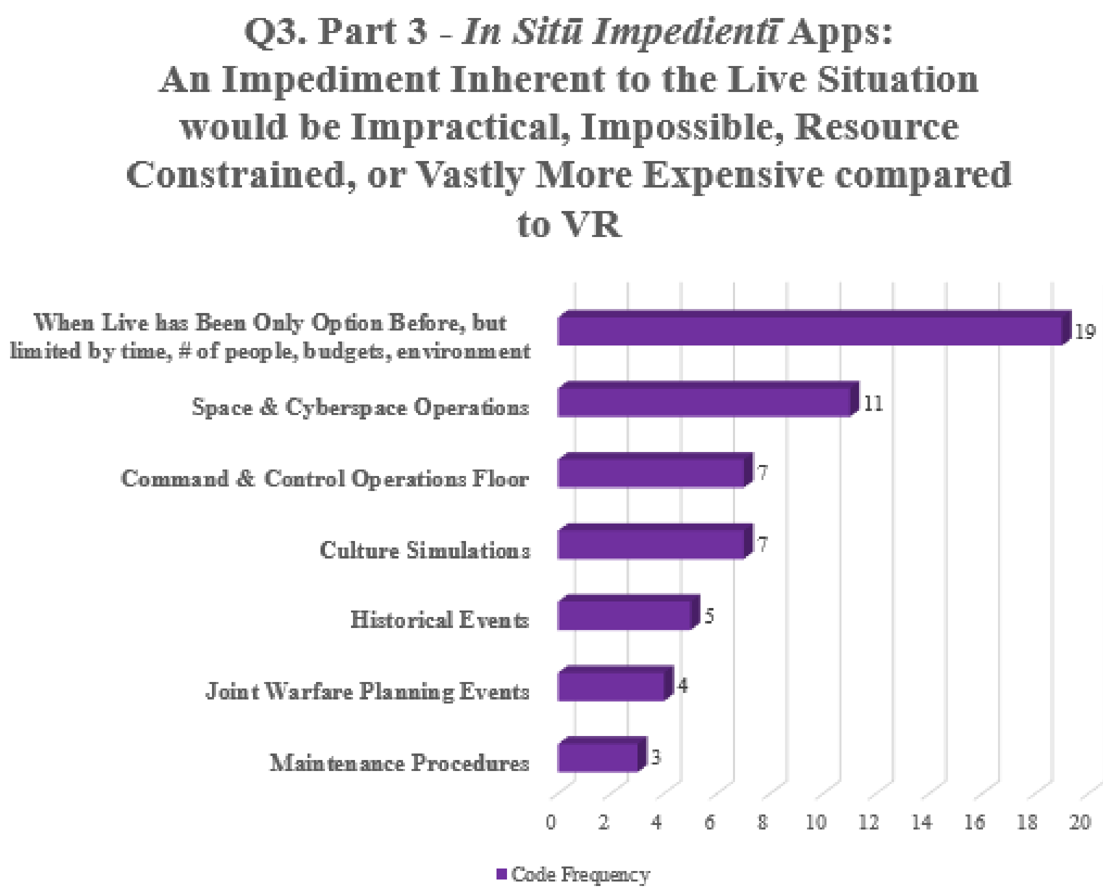

Figure 20. In Sitū Impedientī Apps: Impediment inherent to live situation but not in VR

- The first, and most deeply grounded factor within the theme of *In Sitū Impedientī*, was the factor of "WHEN LIVE HAS BEEN THE ONLY OPTION BEFORE BUT LIMITED BY TIME, # OF PEOPLE, BUDGETS, ENVIRONMENT." Part of the larger degree of grounding, administratively came from the fact that several of data coded for other factors within this theme were likewise coded for this factor as well. However, on multiple occasions, the data coding was due to a broader, less specific case such as the cost of an already occurring program or event.
  - "Training that is too costly to run and organize. This could help in large force training without requiring the whole force. Mission practices, no matter what the mission" (Stakeholder 24).

- “Because in the real world you're trying to do those things it becomes costly, it's more dangerous, you can't repeat it, quickly. In the Virtual world, I can change the scenario pretty quickly if I want to. A lot of the students are saying if I had this in my career field and we had a virtual environment like this where I could go in and we could apply and practice it over and over, this would be helpful … But using immersive environments and virtual environments you can create an experience that's inexpensive” (Stakeholder 35).

Additional factors used in the theme “*In Sitū Impedientī* Apps” have been provided in ALL CAPS, followed by examples of the data that fit within the given factor:

- “SPACE & CYBERSPACE OPERATIONS”
  - “Visualization of orbital mechanics, visualization of satellite overflight/field of view” (Stakeholder 17).
  - “Would enhance the Space Standard Trainer for Space officer training (spacelift, satellite operations, etc.)” (Stakeholder 21).
  - “Just like in an airplane, you can inject emergencies and say, hey. Well, you just got cyber-attacked. You lost this capability. What are you going to do? People have got to make decisions and find ways around it (Stakeholder 33).
- “COMMAND & CONTROL OPERATIONS FLOOR”
  - “(Because our mission is to win or fight wars) …Going from an air operations center to the tasking that goes out to the bases, and then what that base is doing so how that base actually processes that tasking cycle, that order. If you’d just be able to see that process through and see what happens, if you’re at an AOC and how that operation works. Then you're now at one of the bases where the ATO goes there and see how

that base actually executes from it coming down to the wing and it goes down to operations group and it goes through" (Stakeholder 35).

- "VR can also enhance an Airman's understanding of WHAT the Air Force is – bring them to the ops floor (if support) and bring them to the operating room (if flyer) (etc.) and allow for cross-communication to occur through the force" (Stakeholder 01).
- "We should have VR worlds available that gamify the most technical lessons that we teach at SOS (JFO, NCS System). These would work much like the VAOC to help students connect to highly technical and complex topics" (Stakeholder 08).

- "CULTURE SIMULATIONS"
  - "Cross cultural simulations; decision making simulations with tie-ins to ethics, values, leadership" (Stakeholder 12).
  - "cross-cultural simulation would be a great way to immerse students into a cross-cultural environment and would almost certainly be better than the exercise that we currently do for that lesson" (Stakeholder 13).
  - "Cross-culture simulation experiences would be a good addition—the ability to virtually immerse ourselves into another culture where we could make mistakes, learn negotiation tactics and skills, and practice them would be beneficial" (Stakeholder 14).
- "HISTORICAL EVENTS"
  - "Throw students into a historical event or situation and allowing them to be in that world and come up with solutions to those problems and be able to actively play out those solutions in a virtual world and see the effects/results" (Stakeholder 09).
  - "Virtual Museum of Air Force History & Doctrine (Aircraft, Wars/Battles, People, Cyber, Space)" (Stakeholder 10).

- "We're going to put this on and experience George Washington cross the Potomac. We're going to watch this meeting that he had with his generals. Then you're going to be with him in this battle. Then you're going to have an interview with his wife about what it was like to be a pioneer wife. Then, just think about how immersive and memorable that would be. It's like taking a field trip in your classroom. You can go anywhere in the world. That's the capability that VR really brings to education. It's just going to take a little while to get there because it's a lot to build" (Stakeholder 33).

- "JOINT WARFARE PLANNING EVENTS"
  - "VR can provide the visceral comprehensive story of what each service is doing simultaneously during a campaign. If you want us to learn more about Joint doctrine, put us in the cockpit, ship deck, boots on ground, & white house situation room - point of view" (Stakeholder 18).
  - "A decision-based learning activity that places the student in the role of a new Joint Force Commander. This could be used to help students better understand Joint Force Organization basics, to include supported/supporting commanders, COCOM, OPCON, TACON, etc." (Stakeholder 16).
  - "Separate the JAOC director and deputy in another room and have them in a virtual AOC and see avatars of the teams (Goat, Dragon, etc.) and the entire Serengeti map. The other players will be in another room on computers executing their mission like normal but can only hear from their JAOC director via speakers since they will be geographically separated. This would strengthen how to come up with a communication plan for centralized Control, decentralized execution since the JAOC

director cannot just walk over to another computer to point out targets" (Stakeholder 05).

- "MAINTENANCE PROCEDURES"
  - "Maintainers can use this to see how to conduct heavy maintenance like an engine change. Depending on the Maintenance Data Sheet, this may not be a regularly occurring event but they will have seen it at least once in the virtual world. Can even incorporate unexpected damage to challenge their troubleshooting skills (Stakeholder 05).

Theme 3.4 – Opibus Humanis VR apps: practical apps relating to people skills. The Latin term *Opibus Humanis* roughly translates to "Human Resources;" however given that this theme was much broader than the commonly referenced English meaning of "HR," the researcher chose to use the Latin phrase to demonstrate that this theme of VR applications would be more encompassing than just experiences one would have in an "HR department." The types of experiences/applications found within the theme of *Opibus Humanis* Apps relates to social VR experiences that require human-to-human interaction.

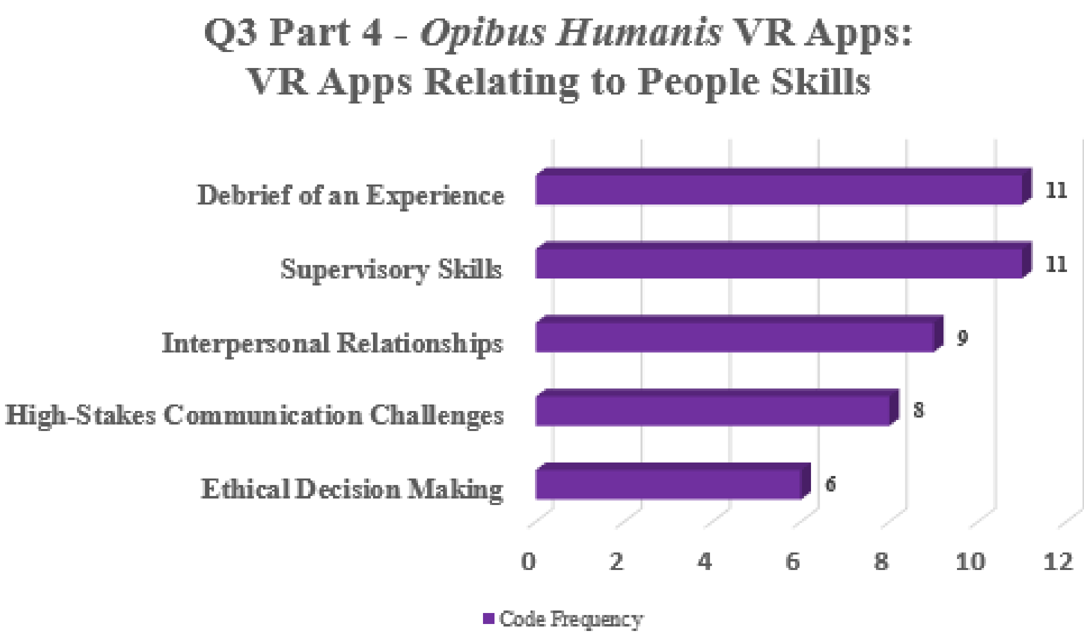

Figure 21. Opibus Humanis VR Apps: Relating to People Skills

- Given that SOC instructors are frequently involved in the process of facilitating experiential learning events, an important component of that process is through debriefing when the experience is connected with the theory. Thus, this factor code within the *Opibus Humanis* theme is: “DEBRIEF OF AN EXPERIENCE”
  - “The instructor course could watch a recorded experiential application from the virtual world, or one that we purposefully create to force certain debrief points, we could more effectively train them on debriefing without actual students present. This would give us more flexibility for how we train them on debriefing and reach those who learn a different way” (Stakeholder 02).
  - “What we do here is the experientials, it's the power of the debrief after the experientials, it's the guided discussions. Becoming good at that it's like anything, it's a skill, and that is a really hard skill” (Stakeholder 38).

- “VR can allow for a “failure” and robust feedback (such as recording performance for students to view post-event and reflect on their performance)” (Stakeholder 01).
- “The two groups with the best time then competes against each other in head-to-head obstacle course with paintball guns. They must apply leadership, followership, communication, strategic planning, and finally effective feedback to win. The results are posted with appropriate introspection on, not the VR experience, but how their team planned and reacted to the problems they faced” (Stakeholder 11).

Additional factors used in the theme “*Opibus Humanis* VR Apps: Relating to People Skills” have been provided in ALL CAPS, followed by examples of the data that fit within the given factor:

- “SUPERVISORY SKILLS”
  - “A decision-based feedback session could be developed that allows students to conduct a virtual feedback session and apply various FRLM behaviors based on what the virtual subordinate displays” (Stakeholder 16).
  - “This could also be along the lines of a movement to bring supervisors to the next level – their troops are using VR for entertainment, and this can be ‘sold’ as a method to help the students relate to their people a bit better” (Stakeholder 01).
  - “A two hour time where they will complete a project-x style task. The two groups with the best time then competes against each other in head-to-head obstacle course with paintball guns. They must apply leadership, followership, communication, strategic planning, and finally effective feedback to win” (Stakeholder 11).
  - “Teaching those leadership skills – they allow me to look at a situation and respond to it. Not necessarily teach me the “correct” choice, but teach me how to make the correct choice. It allows me to be put into my “future me’s” shoes. So I know if I’m

going to be deployed to a location, I could set-up a simulation/build a scenario around ME to say hey, here are some of the things you'll be facing at this location, let's see how you'll deal with it now before you deploy" (Stakeholder 31).

- "INTERPERSONAL RELATIONSHIPS"
  - "Being able to put yourself in someone else's shoes to literally experience what they go through; you create a connection with that. You relate with that in such an emotional way, that all the sudden, your point of view changes. You can't forget it, and it's not that somebody else has changed your point of view; it's that you've come to that conclusion yourself" (Stakeholder 31).
  - "Whoever the user is going to be, that sense of immersion could be anything like from being on a parachute to being on a boat, or even just, "I want to experience a rock concert." Or, I want to see what it's like being a female at a party. I want see what is it like / what does it mean for someone who's going to be talking about forms of sexual harassment" (Stakeholder 31).
  - "As you walk through the scenario, depending on how you led one of the troubled soldiers, he's going to react differently. That can show you that leading your people in the right way, or an effective way, can really be helpful in the battlefield. If somebody's turned on and they're paying attention, they can be a huge asset. If they're not, you might be carrying body bags home. That's a really regretful thing to do. There's that piece" (Stakeholder 33).
- "HIGH-STAKES COMMUNICATION CHALLENGES"
  - "OSI could use it to practice interviewing, clearing a house, testifying in a court martial, etc.- all of the things that we don't have opportunities outside of the formal

schoolhouse to practice until we are actually doing them as live operations. It could even be used as a supplement at the OSI schoolhouse" (Stakeholder 02).

- "In a virtual world, can you actually apply leadership, can you actually apply communication, can you apply problem solving in a synchronous environment where people are in the virtual world (could be in several different locations,) but they're all in the virtual same place. Can you create an environment and how does that virtual environment influence those participants' ability to apply leadership, problem solving? … Aspects of that immersive virtual environment influences them to be able to apply those soft skills" (Stakeholder 35).

- "ETHICAL DECISION MAKING"
  - "We're going through the "What now, captain?" that the PACE folks put out. And they're basically videos that we're using from like an ethics suite, to go: okay, you've heard his point, heard her point, now what do you do? So it's meant to go into ethics and decision making, along those lines. And those are fine, but it's still two-dimensional and not hitting that AFFECTIVE level" (Stakeholder 32).
  - "In particular, VR could potentially be used to place the students in a stressed situation such as an ethical dilemma (you must choose to leave one person behind, or your mission has been compromised and you must select a path that has possible negative connotations). VR can allow for a "failure" and robust feedback (such as recording performance for students to view post-event and reflect on their performance)" (Stakeholder 01).
  - "Cross cultural simulations; decision making simulations with tie-ins to ethics, values, leadership" (Stakeholder 12).

- “Then we bring that into the discussion, as well. It's like, well, what have you found that's an ethical dilemma maybe that was in a situation like this but something you have. Then you can gain those ideas and hopefully incorporate them into future scenarios” (Stakeholder 33).
- “I could definitely see there's a lot of moral conflicts and ethical dilemmas that I would love to shove them into. Knowing, though, that you still have to at the end of if would probably have to say, "You do know that was not faked" (Stakeholder 38).

Chapter Four Summary

This chapter reported the results of analyzing the data provided by SOC Stakeholders through the ITEQ questionnaire and semi-structured interviews as part of the Commander’s “VR in Education Challenge,” and as a component of this case study research. The data were analyzed using ATLAS.ti and categorized into themes which corresponded to the four main research questions. Each primary question & subordinate theme was segmented into codes that represented factors to provide the “raw answers” to the research questions. The next chapter will interpret these results in terms of the researcher’s conclusions and recommendations.

Chapter V: Conclusions, Recommendations, and Opportunities for Further Research

As Virtual Reality (VR) and Augmented Reality (AR) devices become more ubiquitous and, resultantly, as the ability to use "first-person presence" as a learning tool becomes more within reach, research is needed about how this new capability can best be used for education. The present research used the case study of the Air University's Squadron Officer College (SOC) as implemented through the "Virtual Reality in Education Challenge" to provide greater understanding on how to use VR as a learning tool in the Professional Military Education (PME) sector of higher education. Based on the results from the study as analyzed in chapter four, this chapter provides the researcher's concluding evaluation and synthesis of those results into recommended courses of action and suggested opportunities for further research.

Purpose of the Study

The aim of this research was to inform the Air University policy process, curriculum development efforts, and instructional practices on strategies to enhance and support the integration of VR into the graduate PME learning environment. The study sought to identify the elements that would be potential challenges, means to overcome challenges, and opportunities for integrating Immersive Technology into the learning environment and to synthesize a compilation of potential VR applications with relevance to PME and grounding in time-honored educational and social science theories. These challenges, opportunities, and applications should provide important foundational information for other higher education institutions seeking to use VR as a learning tool. Further purposes of the study were to provide a model that might be of value to others interested in using VR in the teaching process and to enhance the literature on this important topic.

Re-Statement of the Problem

For generations, educational theorists have professed that deep learning occurs best when learners actively participate in or have experiences as part of their learning activities (Brown, 1989; Bruner, 1982; Dewey, 1938; Friedman, 2005; Kolb, 2014; Lave & Wenger, 1991; Weigel, 2002; Winn, 1993). Given recent advances in consumer technology, virtual and augmented reality technologies present new opportunities for learners to engage with subject matter visually, audibly, and tactilely in "first-person" perspective – and thus to have a unique experience as part of the learning process. U.S. Air Force senior leadership has expressed a strong interest in investigating new technologies that have "game changing" potential application in education (James & Welsh, 2015). Considering these factors, the higher education field, and in particular, the Air University (responsible for all Air Force Professional Military Education – PME), has a need to be informed on the nature of VR and AR in order to better evaluate opportunities for investing in these technologies as learning tools. Likewise, the Curriculum Development and Instructional Delivery communities at large have a need to understand concrete ways that the new technologies can be used to effect desired learning outcomes.

Research Questions

1. Central focus: (Negatives & associated inverse positives) – Challenges and surmounting strategies anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

   Q1a. What are the potential challenges to integrating VR into the SOC learning environment?

   Q1b. What strategies/ideas could be used to overcome these potential challenges?

2. Central focus: (Positives) – Potential opportunities anticipated by SOC Stakeholders in the integration of Virtual Reality as a tool in the learning process:

Q2. What are the potential opportunities for SOC in using VR as a learning tool?

3. Central focus: Practical applications of VR identified by SOC Stakeholders as having best potential to improve learning outcomes:

Q3. What VR content (current or future applications) would have the most impact on SOC student learning?

Force Field Analysis on Integration of VR as a Learning Tool at SOC

The present research addressed each of the research questions to a purposeful sample of SOC Stakeholders using the ITEQ open-ended questionnaire and recorded semi-structured interviews as described in chapter 3, Research Methods. The results of these research activities were analyzed in chapter four and provided the baseline data for the conclusions and recommendations as presented in this chapter. The following chart presents a summary of the findings from Questions 1a/1b, and Question 2 in the form of a Force Field Analysis. The Force Field Analysis is a tool used in social sciences to visually depict the forces that negatively influence a specific problem or opportunity in opposition to the forces that positively influence the problem or opportunity. German-American Psychologist, Kurt Lewin, in his 1943 paper, *Frontiers in Group Dynamics,* and other seminal works about group dynamics and field theory, provided the model for the action research tool known as the Force Field Analysis (FFA). Using this tool, a visual display is depicted in which the fundamental negative factors (or challenges) working against a change or opportunity are shown in visual contrast to the primary positive factors (strategies to overcome or opportunities) that work in support of the change or opportunity. In the present research, challenges were identified via Question 1a and were demarcated into 3 themes (technology-based, leadership-based, and curriculum-based challenges). On the positive side of the FFA, strategies to overcome challenges were identified by question 1b and demarcated into 2 themes (faculty-based strategies to overcome and non-faculty-based strategies to overcome). Likewise, on the positive side, opportunities for VR were identified by Question 2 and were demarcated into 3 themes (the *Phenomenon of VR*, the *Use Cases for VR*, and *Unique Stakeholder Groups*). As displayed in Figure 22, per the qualitative data provided in the present research – as coded and interpreted by the primary researcher and validated via peer checking – the positive forces in support of integrating VR as a learning tool at SOC were greater in number than the negative forces. The primary aim was not to draw a "quantitative" conclusion such as, "since positive forces totaled at 263 combined codings compared to 241 combined codings for negative forces, there was 9.12% greater force in support of VR as a learning tool at SOC." Such a conclusion would be naïve and counter-intuitive to the value of qualitative research. Since all the data analyzed were products of subjective views, and each code applied was consequent to the primary researcher's subjective analysis of the data, attempting to definitively quantify the result was not the focus. The true value of this chapter's conclusions, recommendations, and suggestions arises from the reality that having analyzed the data provided in this case, and having constructively evaluated those data in light of extant research, the researcher's expertise on this particular case study can be considered as competent and trustworthy to produce conclusions and recommendations on the subject.

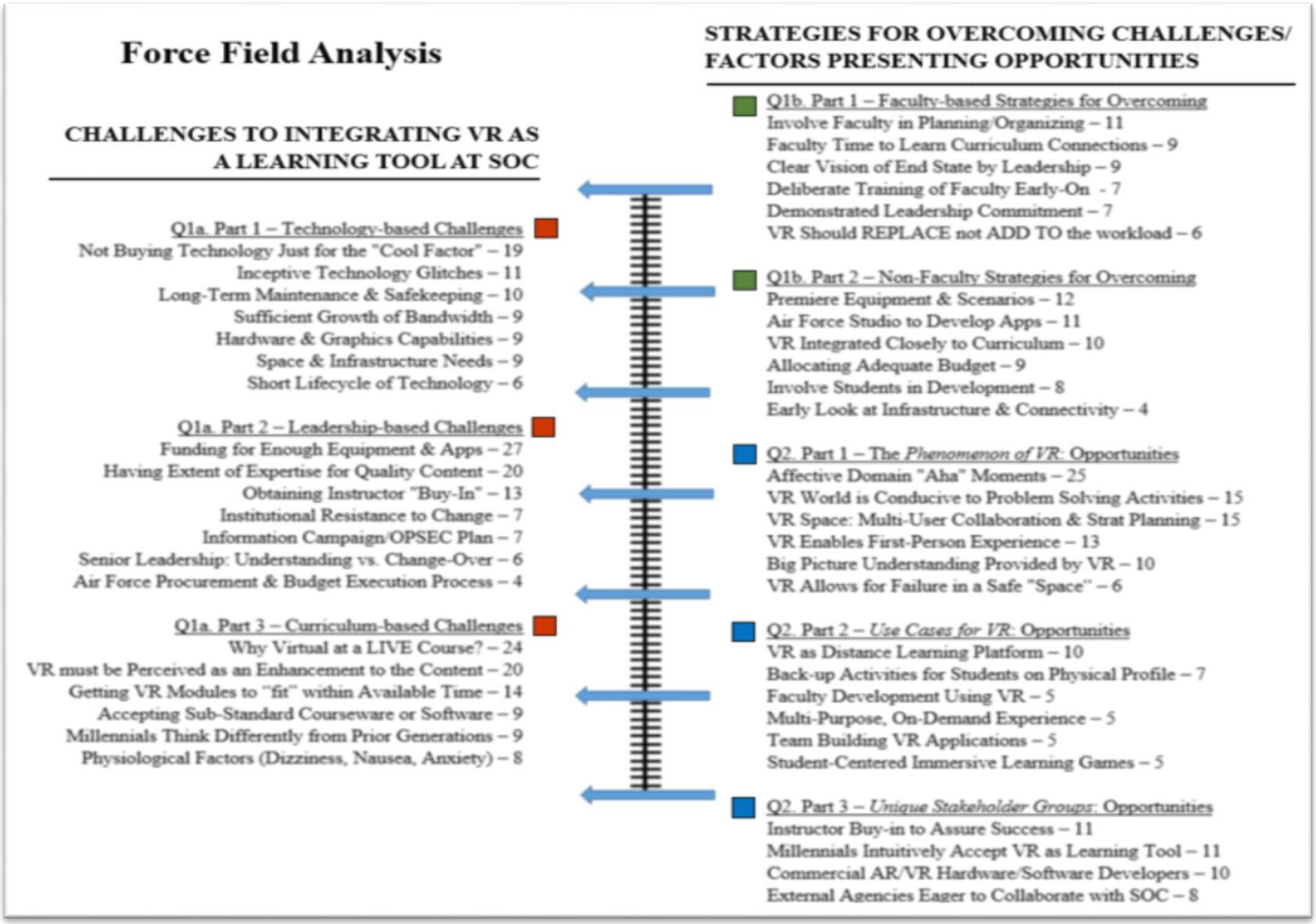

Figure 22. Force Field Analysis – Challenges vs Strategies to Overcome/Opportunities

Conceptual Framework in Reference to ISD

As noted previously, the Air University model for curriculum development is known as Instructional Systems Development (ISD), which was described in detail in chapter one. In Figure 24, "Challenges Related to Components of the ISD Model with Strategies to Overcome & Opportunities," each of the challenge themes has been identified as corresponding primarily to a principal functional area (Management, Support, Administration, Delivery) and/or to a particular phase of the ISD process (Design, Develop, Implement, Analyze, Evaluation). These designations were made based on a logical correspondence with relation to the business processes inherent to SOC, and as such, the reader can re-interpret these designations depending on his/her own organizational demands. Interspersed among the challenge themes also has been suggested the primary "positive force" themes. While no one specific functional area or phase of the ISD process is likely to correspond exclusively to a specific theme or factor, a reader may reference this model based upon where his/her position "fits" into the instructional systems process and gather a wider sense of understanding on the challenges, strategies to overcome challenges, and opportunities with relation to using VR as a learning tool in his/her organization.

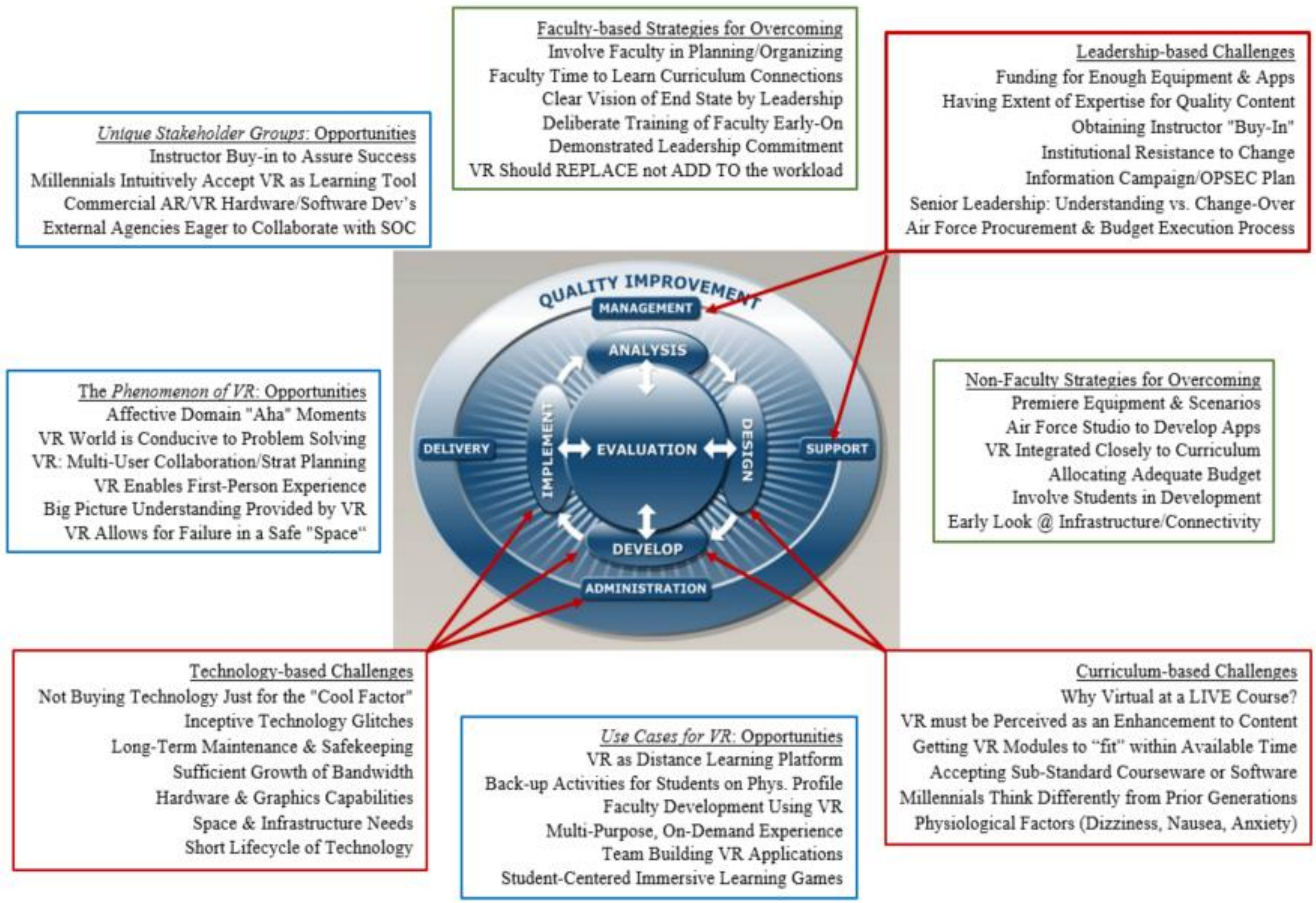

Figure 23. Challenges Related to Components of the Air Force ISD Model with Strategies to Overcome and Opportunities

Question 1a. Challenges to integrating VR into the SOC learning environment

Each of the primary themes identified within the question of "challenges to VR" brings a wide array of implications to an educational organization that is interested in using VR as a learning tool. By better understanding the potential challenges as articulated in this section, an organization can better prepare for the future if the plan includes using VR as a learning tool.

Technology-based challenges to integrating VR. As with many of the technology-based challenges, the central aspect to the point of "not buying new technology just for the cool factor," is psychological. Having an institutional mindset that merely acquiring a new technology will result in improvement is not likely to be successful. According to M.B. Hertz's, writing in *Edutopia*, the idea of, "If it's cool, it will engage …" (Hertz, 2015) is a complete myth. Unless the new technology is part of a broader set of plans to improve student outcomes with a defined curriculum connection, a plan for faculty development, and specific arrangements for long-term maintenance of the technology, the end result of a technology investment can actually become more of a liability to an institution than an asset.

From the perspective of Maintenance & Safekeeping of technology resources, an organization must purposefully budget for the right amount of technical support staff and resources to adequately keep the technology running and reliable. The down-time that can result from an asset that has been neglected can often be much costlier than the additional funding that would have been expended to have paid for preventive maintenance on the asset. Regarding Bandwidth, the current generation of VR technology is generally considered bandwidth-intensive for existing network architecture. If a school expands the curriculum toward increased use of VR as a central part of the program, the consideration for the number of users multiplied by the amount of bandwidth per use must be considered in future planning for network architecture.

Likewise, the amount of space and infrastructure (electrical, storage, etc.) that would be required needs to be a logistical consideration before investing in a technology venture. By working with (and closely listening to) network architects and computer support personnel, leadership of a higher education entity can avoid many technology-related challenges that result from investing in under-performing network capacity.

"Inceptive Technology Glitches" are always a real challenge when a new technology is being introduced. In this realm, it is the "unpredictable" aspects about the new technology that become the essential challenges. The term, "inceptive glitches," is a reference to the arbitrary problems that often are not described in early versions of trouble-shooting guides because they commonly are not foreseen by even the engineers, manufacturers, or programmers. The direct experience of the VR Lab Team in this aspect of investigating VR was telling: during the research, hundreds of hours were spent working to make the VR development kits operate smoothly. The more cutting-edge the technology is, the more numerous and likely inceptive technology glitches will take the organization by surprise and drain technical support manpower during the early phases. When unusual malfunctions are diagnosed on an early-generation technology item, often, the recovery process is burdensome. Meanwhile, during the time that the asset is down for repair, it cannot be used to deliver learning outcomes. This point is amplified by another myth referred to by Hertz: "Myth … If the intention behind the product is good, then it can only do good in the classroom" (Hertz, 2015). Regardless of how well-intended a new technology investment may have been, when early-stage, unsolvable problems plague an education technology program, educational outcomes suffer. If an organization does not have the right complement of technical support personnel to operate early-stage technology, a wise course of action may be to wait until the technology is more proven before investing in it extensively so that a greater amount of supporting documentation or perhaps even a technical support hotline would be available. Because technology lifecycles move rapidly, devices that are currently in the "early adopter" stage, within a few short years will likely have a more mature ecosystem of support to rely upon when glitches occur.

Leadership-based challenges to integrating VR. Throughout the data collection, the most firmly grounded factor within any theme was the issue of funding required for sufficient hardware equipment and software applications. Historically, funding for both hardware and software have made VR in Education a cost-prohibitive endeavor. At ten-thousands to hundred-thousands of US dollars per user for suitable VR hardware, the equipment alone precluded all but the most elite educational ventures from implementing VR as a learning tool. Now that the per-user cost of VR hardware is at a realistic price point, the next challenge will be to get costs of subject-matter-specific VR experiences into the realm of "realistic" for VR to proliferate in education. Several of the participants in this research identified the need for "VR maker tools" to be the key to seeing this cost decrease. Leadership of educational enterprises would be prudent to keep a watchful eye on the market looking for the new "killer app" that enables fairly novice users to create within "VR Space." Choosing from a pre-existing library of digital VR "objects" and characters and being able to manipulate those objects and characters as desired to produce high-quality, self-generated VR experiences would likely be the "killer app." Having a high degree of experience with a "VR gaming engine" such as Unity, Unreal, or CryEngine should not be the "cost of entry" into "VR Space."

While the quest for this user-friendly suite of "VR maker tools" is on the horizon, leadership must still focus on the reality that instituting a new tool that uses "first-person" for experiential learning encounters will doubtlessly be a fundamental change in educational design and delivery. As discussed in the literature review, the educational foundations supporting experiential learning have been well-established over the past century. Experiential learning, constructivist learning theory, and situated cognition are all keys to deep learning, and likewise shown to be manifest with VR. To take advantage of the availability of these factors, educational leaders will be faced with the challenge of dealing with (and ideally, overcoming) institutional change and obtaining "buy-in" from key stakeholders. Obtaining buy-in can be helped, partly, by having an on-target information campaign or strategic communication plan. Particularly within the department of defense, the information campaign should also consider Operational Security as a key factor.

Curriculum-based challenges to integrating VR. The second most-highly coded factor within challenges to VR related to the question of "Why virtual at a LIVE course?" This factor becomes a challenge in the realm of the curriculum since the curriculum, particularly at in-residence education programs, should accommodate for the reality that LIVE offers a higher "bandwidth" of experience due to providing input to all of the learner's sensory systems as well as involving in-person social learning. The big challenge for those in the in-residence curriculum development field is to determine "when live?" and "when virtual?" One guide to answering these questions hinges on understanding the answers to the last question in the present research, or "Practical Applications for VR." By knowing what types of applications are ideal for VR, a curriculum developer can be more certain that the second factor within this theme is accommodated - that VR will be perceived as an enhancement to the content (e.g. *In Extremīs* – or situations where the experience could get one killed, as well as *In Sitū Impedientī* - or situations that provide an impediment that cannot be overcome.) Each of these categories of VR applications relates to offering learners an experience that would in no way be feasible in a traditional classroom setting.

Some other commonly-voiced factors within the theme of “Curriculum Challenges” involved making sure that VR modules “fit” within available time in the program and not accepting sub-standard VR applications. The essential points to these factors involves making sure that students’ and instructors’ time is valued. Poor quality VR often results in dizziness or nausea, and at minimum cheapens the learning process; at worse, makes students sick. To avoid these negative repercussions, the curriculum should take into consideration that today’s millennial generation expects for technology to work smoothly. From the outset of the VR integration effort, if sub-standard simulations are used, or the VR is not seen as an enhancement to the curriculum, the program will suffer a rapid death. Resultantly, the resources invested into a sub-par quality VR curriculum could have been better used if invested into a more mature technology that already has proven ability to enhance outcomes.

Question 1b – Strategies/Ideas to Overcome Challenges to Integrating VR at SOC

The second part of this research question is based on a pragmatic focus: whenever one identifies a problem or challenge, unless one also identifies, or at least attempts to propose a solution, one merely becomes a part of the problem or powerless to dealing with the challenge. SOC Stakeholders who participated in the Commander’s “VR in Education Challenge,” naturally were eager to provide their inputs on proposed strategies to deal with the problems of integrating VR into the learning process.

Faculty-based strategies to overcome challenges. SOC Stakeholders’/research participants’ eagerness to address the challenges of VR integration, (along with the fact that most of the Stakeholders were in some manner part of the faculty), carried-over to become the primary theme, that of “Faculty-based Strategies to Overcome Challenges.” The same eagerness resulted likewise in the top factors illustrated within this theme: those of direct faculty involvement. Whether being involved in planning and organizing the effort, taking adequate time to learn curriculum connections provided by the technology, acquiring a clear vision of the technology’s intended end-state, or participating in deliberate training, faculty want to be involved if there is a “wholesale-level” change in content delivery such as that which integrating VR would involve. If leadership of the organization shows the right level of commitment to the outcomes that the technology would be used for, and leadership determines that the technology will be integrated not “in addition to” but “as replacement for” other content, the faculty will be much more eager to accept use of the technology and help overcome many of the challenges to VR integration. It is important to note that VR is but one tool among many, and that it should be used in cases in which it provides a better scaffolding to intended learning outcomes than other alternatives.

Non-faculty-based strategies to overcome challenges of integrating VR into the SOC learning environment. Beyond the faculty-based strategies, SOC Stakeholder/research participants identified several “non-faculty-based” strategies to overcome challenges to VR integration. Key among these strategies was that using Premiere Equipment and Scenarios will help overcome several challenges. The statement that “… our students don’t suffer poor technology” (Stakeholder 32) gives rise to this key strategy. Before a VR device or application is introduced to the students, it must be met with positive acclaim from beta testing. At the end of procuring a piece of hardware or producing an application, it would be best to introduce it into the curriculum only if beta testing shows that it meets the objectives of being considered high quality and likewise is closely integrated into the curriculum. In addition, allocating adequate budget and involving students in the development of efforts to use VR, will help overcome another host of challenges. One of the well-grounded non-faculty strategies suggested the idea for an Application Development Studio. Such a studio would need to be adequately funded and comprise of experts who can develop VR applications in accordance with the educational objectives as expressed by educators. This non-faculty-based strategy is further discussed later in this chapter under the recommendations section.

Question 2 – Opportunities for SOC in Using VR as a Learning Tool

Sometimes the best approach to overcoming a challenge is not to address it head-on, but to take advantage of other opportunities in the operating environment to the extent that the challenge no longer exists or becomes less irrelevant. This is the notion behind question #2 which asked SOC Stakeholders to address opportunities of using VR as a learning tool.

Factors attributed to the phenomenon of VR: opportunities. The first theme within Opportunities for VR is the theme of the phenomenon of VR being so unique that it is an opportunity. What SOC Stakeholders identified most overwhelmingly within this theme – and, incidentally the most highly noted factor in the entire research study was the fact that VR works as "first person" within the Affective Domain to enable definitive "Aha" Moments. This is the factor that demonstrates VR to be a real "Game Changing Technology." Never before has a learning program been able to transport learners to so many places – along with other learners to experience something – even at different periods in time. The ability of VR to create empathy within the mind of the learner by presenting first-person perceptions of person/place/time/method is a substantial aspect of the technology that enables the Affective domain to be addressed. Within the "world" of VR, students can solve problems, collaborate with other users, engage in strategic planning, and better understand the Big Picture. Given that one of the goals of learning is to learn "how to fail," VR opens the door to an infinite world of possibilities in which a learner can try, fail, try again and again, and eventually succeed (all within a safe “space”). Accordingly, this type of informal, experiential learning, as advocated by Jean Piaget, is at the heart of constructivist learning theory and relates back to the overall paradigm of Constructivism, Experiential Learning, and Situated Cognition being the heart of learning using VR.

Factors attributed to use cases for VR: opportunities. When addressing the opportunities for using VR, SOC Stakeholders often identified particular cases in which VR would be a useful tool. First among those use cases was the area of Distance Learning. Students who attend PME via distance typically never visit a central location in person; (the location would have been Maxwell Air Force Base in the case of in-residence SOC students). Because distance learning students are geographically dispersed, they are not afforded the same opportunity for face-to-face group collaboration that in-resident students experience. VR could theoretically make such collaboration possible. By “virtually” joining their peers in a collaborative VR space, distance learning students, or in-resident students who have been physically disqualified for participating in certain events due to injury, can easily “teleport” into a shared VR experience to participate “face-to-virtual-face” in team-building applications with their distance learning peers.

Another key use case expressed by SOC Stakeholders was the idea of participation in selected Faculty Development learning experiences via VR. Sometimes, faculty members join the SOC staff at a point in time that the formal faculty development class is not being conducted. If simulations were built that allow faculty members to practice certain teaching skills with a class of virtual students (who interact based on pre-determined artificial intelligence algorithms), then faculty members could participate in the chosen portion of learning even when formal faculty development classes are not in session. Likewise, if an instructor would like to brush-up on a teaching skill, at any time, he/she could don VR gear and practice; thus, making practicing the skill an on-demand experience.

In chapter 2, the literature review provided a synopsis of the concept of "Games in Education" – this was discussed by SOC Stakeholders as a use case for VR. Because learning games are naturally student-centered, one side of the appeal of using Learning Games is self-evident. While the main market for VR until now has been in $90+ billion global video game market, it should naturally extend that some of the better early cases of using consumer VR may become the area of student-centered learning games. As noted also in chapter 2, Flow Theory, as espoused by Mihaly Csikszentmihalyi, provides sound support to the idea of educational games for attributes such as the learning experience becoming autotelic in that the learning game activity itself becomes inherently motivating. The goal here would be that students would actually look forward to completing their PME because the experience in itself is rewarding.

Factors attributed to unique Stakeholder groups: opportunities. An important group of stakeholders that provide a unique opportunity is the group of SOC instructors. The majority of SOC Instructors (and likewise students) at the present time are from the millennial generation. Accordingly, they are naturally inclined to "buy-into" VR as a learning tool. This factor is fortuitous for SOC given the previous theme under question #2 that clearly demonstrated the need for instructor buy-in. At the present time, the software development world is eagerly looking to produce compelling content. That opportunity presents itself to SOC and other higher education programs to lock-arms with worthy VR development studios to build powerful educational content. Without educators to guide content development efforts by providing first-rate quality content ideas that are compelling, commercial gaming developers can just as easily default to “lowest common denominator” content that has little redeeming learning or social value. Meanwhile, as SOC has already been in collaboration with Stanford, Auburn, Georgia Tech, MIT and many others regarding VR in Education initiatives, these institutions, along with several other educational enterprises are eager to forge ahead with expanding even broader collaboration agreements to ensure that VR takes a prominent seat in the domain of experiential learning.

Uses applicable Air Force-wide (not just at SOC): opportunities. This research endeavor did not have as a primary focus the intent to investigate the full range of possibilities in which VR could be used as a learning tool across the entire Air Force: such a study would be a much more extensive endeavor than a single doctoral dissertation. Instead, however, in the consideration of questions to be asked during the internal SOC-administered ITEQ study, SOC leaders suggested to include a question regarding opportunities to use VR throughout the greater Air Force. This question was posed as a measure to stretch Stakeholders’ thinking on the subject with a desired outcome of stimulating broader ideas on the true subject of focus for the present study: that of using VR as a learning tool at SOC. Once these Air Force-Wide Opportunities had been captured, the data presented a worthwhile opportunity to serve as a baseline for contributing to a potential future, broader study on possible ways VR may be used Air Force-Wide.

This theme of Air-Force-wide Uses did indeed contribute toward enhancing the SOC-focused uses of VR: the primary factors identified within this theme were those of “Experiencing Unique Missions & Sharing Lessons Learned,” along with “Ancillary/Expeditionary Skills Recurring Training.” Both of these categories provide impact to SOC’s mission. Experiencing Unique Missions is an area that would provide SOC students with the outcome of better understanding different mission areas outside their own. From a cognitive domain perspective, these experiences would enable students to analyze and evaluate mission areas that are outside their own usual fields – higher-order levels of Bloom's taxonomy. Affectively, valuing diverse cultures, inter-agency contributions, joint service mission sets, and other career fields would be the goal for this type of experiential learning. This broader understanding of the Air Force mission provides additional support to the opportunity to use Experiential Learning as a core strategy to achieving learning outcomes.

The Ancillary/Expeditionary Skills Recurring Training factor relates to semi-annual, annual, or bi-annual requirements that all Airmen have: the requirements to watch the same computer-based training (CBT) sessions that some participants described as mind-numbing. Yet, the very subject matter at the focus of these CBTs happens to be life-saving and critical for survival while one is deployed. Developing first-person experiential learning scenario-based learning games in some of the more uninspiring blocks of ancillary training would be an ideal area to apply VR on a beta test.

Another key factor brought forward by the theme of Air Force-Wide uses of VR was the idea of improved government/industry partnerships. This could be envisioned through the use of social VR platforms to host Air Force forums that open dialogues about topics of common interest between the Air Force and industry partners. These forums could supplement existing live forums and occur more frequently and would be less expensive to attend. Such forums could serve toward building an ongoing dialogue in preparation for future live events.

Perhaps the most profound factor within the theme of Air Force-Wide uses of VR was the factor of experiencing history of the Air Force in first-person. This is an idea that would provide impact even beyond the Air Force. To encounter a flight onboard the first Wright Flyer with Orville Wright at Kitty Hawk would be a memorable experience: one that perhaps all people would be inspired by. To fly with Billy Mitchell on an aerial bombing run over the first ship to be sunk by aerial bombing would serve to invigorate Airmen that ours is a heritage of thinking about opportunities first – in an effort to make our challenges less relevant.

Question 3 – Current or Future VR Apps with impact on SOC learning

In keeping with the overall pragmatic focus of this research project, the final research question relates to practical applications of VR. This question sought to discover specific situations that would provide experiential learning opportunities to be translated into VR applications for the purposes of improved learning outcome at SOC. Figure 26 provides a summary of the four themes discovered within this question, along with the individual factors. identified within each theme.

***Status Quo* VR apps: sub or supplement existing SOC programs.** Whenever a disruptive innovation first appears, stakeholders who have strong attachment to existing processes initially tend to measure the innovation in terms of how well the innovation approaches solving existing problems or how it improves the ability to operate within the current process. It is for this rationale that the theme of "*Status Quo* VR Apps" was developed. These VR Applications are apps that could substitute for or supplement existing SOC Programs. The first two types of applications within this theme are Decision Making Simulations and Stressed Situations. The SOC curriculum is filled with Stressed Situations and multiple Decision Making Simulations in which the student makes decisions based upon pre-determined scenarios. By introducing a simulation that affords similar simulations or scenarios, the use of VR could be compared to similar exercises done "live." Most likely, the ability to accomplish the same scenarios would have greater impact in the case of "live" execution; however, not every student can execute “live” stressed situations – particularly when there is a physically strenuous aspect involved – or when the student cannot appear “live” (i.e. the case of distance learning students.)

One of the capstone experiences at SOC is the execution of ADWAR (Airpower Doctrine War Gaming). Multiple Stakeholders participating in the present research advised that including a component of VR in the ADWAR experience would possibly add some additional “big picture” understanding of the execution of a large force airpower engagement. Likewise, research participants advised that accomplishing “Project-X” or some of the Team Leadership Problems (TLPs) by using a VR component could enhance the current experience. Students who can’t complete these experiential exercises, again due to physical profile, would be able to accomplish those learning outcomes. Accomplishing a virtual version of Project-X or TLPs as practice for the “live” versions may have utility.

***In Extremīs* VR apps: death/extreme danger evident if live.** The first theme for VR applications in which live has never been a realistic option in an education program is the category of *In Extremīs* VR Apps, or applications in which death or extreme danger would exist if accomplished “live.” Even a disinterested outsider to the profession of arms could describe countless scenarios in which military personnel could be exposed to death or extreme danger. Yet, never before in history have these scenarios been available as a first-person experience to use as tools in the affective domain for the purpose of achieving learning outcomes. Certainly, the point here is not to imply that the authentic danger of an *In Extremīs* situation could be exactly reproduced in VR; however, the reality that physiological data and MRI data support the notion of affect being real in VR does provide some affordance to I*n Extremīs* simulations having at least some degree of realism in VR. The participants in the present research identified multiple key simulation scenarios that would enable just this type of affective experience.

The first *In Extremīs* scenario identified by the participants was the idea of Aerial Combat & Flying Operations. This was the most frequently cited factor throughout question #3. For students who are not part of the flying operational community, the ability to see a Red Flag execute from the first-person eyes of an operator could add value to their understanding of the operational Air Force mission. Likewise, for air-to-ground combat aviators to experience the explosive ordnance disposal technician's viewpoint of a post-engagement could provide insight to another part of the mission. Experiencing the first-person situation of people impacted by unintended civilian casualties could provide great empathy for the necessity of operational planning and execution to deeply consider this perspective. For all non-medical personnel to experience in first-person what life is like in a trauma center during a mass casualty scenario or facing the reality of having to provide care to a wounded enemy combatant would provide a great degree of empathy for fellow service members serving in those parts of the mission. If the opportunity existed to experience a post-attack disaster response scenario prior to having one actually occur, it would have a profound positive impact on warriors' readiness to act during a real incident.

***In Sitū Impedientī* VR apps: situational impediment prohibits live**. In VR, it is possible to even have a first-person experience of taking a "zero-gravity walk" on the International Space Station or "fractional-gravity 'bounce'" on the surface of the moon. These *In Sitū Impedientī* applications have the inherent impediment that (in the current day) less than 500 humans have ever been able to experience them. In Virtual Reality, having a first-person experience of seeing a Deep Water Horizons undersea environmental problem to produce greater crystalized affective domain critical thinking on the subject is entirely possible. VR frees the bounds of thinking for the curriculum developer. Add to these *In Sitū Impedientī* applications the reality that certain things occur infrequently and cost great sums of resources to have people experience them “live.” By staging 360-degree cameras on operations floors during execution of a major joint exercise, the possibility comes open to use the “first person” view of the exercise executing as an education and training tool for future staff officers. Or, by building culturally-accurate scenarios, students can be introduced to cultures abroad for the purpose of cultural understanding prior to actually travelling there. If a specific affect is desired and could be met by placing the learner first-person in a specific social setting at a particular place in time, VR allows that. Learning how to use “first person” as a learning tool is going to require a dramatic change in how we think about curriculum. In the future, to write a scenario-based learning objective, a curriculum developer does not only need to think about what and how, but also where, when, and with whom (alive or historic)?

Opibus Humanis **VR apps: practical apps relating to people skills.** In the theme of *Opibus Humanis*, or “Human Operations,” our SOC Stakeholders identified first, the process of “debriefing an experience” and “supervisory skills.” The first one is a practical skill used daily by SOC instructors. This perspective is that instructors could train on the process of debriefing an experiential learning event by using a VR scenario. Also, supervisory skills are those that are focused-on heavily in the SOC curriculum; this, along with the similar “interpersonal relationships” is an area in which the participants thought learning outcomes could be greatly enhanced with the use of VR applications. When the goal is higher-level learning outcomes, or critical thinking, in the affective domain, the reference point is to characterize a set of values from one’s own value set. The factors within this theme that become of utmost importance are those like “high-stakes communication challenges” (diplomatic, coalition, military-to-military communication engagements) and ethical decision making (law of armed conflict decisions). If the ultimate goal of PME is to produce critical thinkers who act with core values, then the course of using tools that approach the affective domain with critical thinking level of learning tools would be a wise course of action.

Implications for Action

International Data Corporation (IDC) predicted sales of consumer VR and AR headsets to grow to over 100 million units annually by 2021 (James, 2017). If this prediction comes to fruition, considering that actual sales in 2016 were 10 million, this would result in a ten-fold increase in the number of units per year for the five-year period 2016-2021. Put into present terms, over the next 5-10 years the proliferation of VR and AR devices will follow the pattern of ubiquity that occurred with smart phones over the past 5-10 years. The implication of this trend is that while VR devices proliferate, educators should move ahead of the mass and work toward developing important learning content that takes advantage of the devices that will be in the hands of their target market: students. As extensively expounded upon throughout the present study, using the educational foundations and theories that underpin Experiential Learning will be a key factor for successfully implementing VR in education.

Kolb's Experiential Learning Cycle. As described in chapter 3, Experiential Learning Theory as espoused by David Kolb in 1984 is an important model to use for experiential learning in VR. SOC already relies upon the ELT model (shown in Figure 28 below) as a resource in facilitating learning experiences. Each of the experiences that would be used in the VR realm can likewise be taught through application of the ELT model.

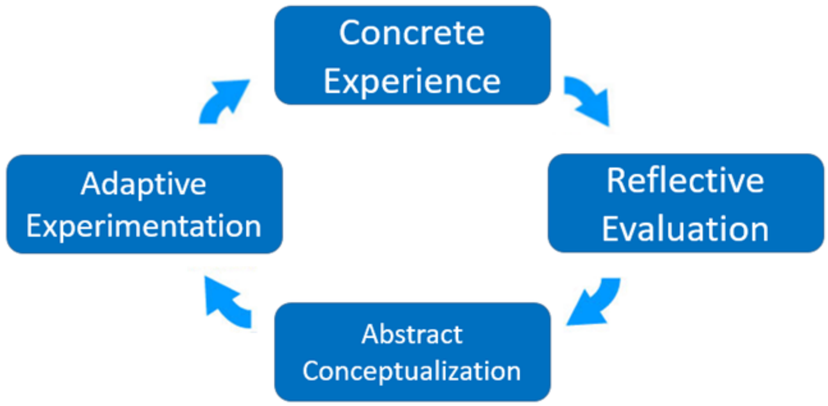

Figure 24. Experiential Learning Cycle

Once the VR learning experience is encountered (concrete experience) – ideally by an entire group of learners simultaneously – the students would reflect on observations (reflective evaluation) taking particular notice to differences between the experience and theoretical expectations. Next, the facilitator would encourage the learners to model a new idea (abstract conceptualization) that brings the knowledge to a higher level of understanding. In the fourth step of the cycle, the learners would apply the new understanding to the world (adaptive experimentation) – or back in the VR simulation – for a new concrete VR experience. It is important to note that throughout the ELT cycle, the focus is not only on the "app," but on the pre- and post- activities that occur to connect the experience to the theories and concepts that are the real intended learning outcomes. Just as it was noted not to pursue technology just for the "cool factor," an experiential simulation is not engaged just for the simulation alone: it is when the experience is connected through conceptualization and adaptive experimentation that the learning actually occurs.

"VR in education" technology incubator cell. Considering the high likelihood of VR and AR technologies becoming tools for everyday life in the medium-term future, at the current point in the lifecycle of VR technology, it would be wise of higher education institutions like Air

University to implement a program such as a "technology incubator" program. Under such an initiative, the program would remain limited in scope such that a vast amount of resources are not expended on un-proven hardware and software applications so as to risk not accomplishing educational outcomes. Such an incubator, similar to how the Virtual Innovations Learning Lab at SOC has done, would continue to investigate the technology and experiment for productive, highly-leveraged applications. Perhaps the first deliverable target would be a set of VR learning activities that would augment existing PME lessons as supplemental material; then next, a target deliverable could be to produce a voluntary course using VR that could be executed as a blend of in-residence and distance students in a beta test. Additional milestones would be placed for this "VR in Education" incubator cell. In addition to deliverable milestones, a key area of involvement for such an incubator cell would be to continue the dialogue on opportunities for using VR as a learning tool and scanning the best practices across the VR educational initiatives throughout the world. Continued collaboration among similar "VR in Education" incubator cells would encourage development of a "community of practice" through multiple educational institutions and take advantage of the diversity of ideas provided by a wide variety of disciplines.

VReX – Virtual Reality Educational Exploration: proposed new app. The idea for a specific new VR learning platform developed resulting from synthesis of many SOC Stakeholders' ideas. This idea springs also from the primary researcher and VR expert colleagues' experiences in assisting multiple first-time VR users in examining the Oculus Rift DK2 for the first time. The key challenge in demonstrating immersive VR relates to the chore that SOC ADWAR specialists refer to as "button-ology." Learning what settings to arrange, which buttons to press, etc., is a tedious process initially for all new immersive VR users that detracts from the planned learning experience. Added to this challenge is that while wearing the device, participants cannot see the facilitator. Just as when learning to live aboard a ship for a period of time, one has to develop, “sea legs,” the VR community has colloquialized the term, “VR Legs” as a parallel that references being accustomed to the physiological differences of perceived motion – as well as physically accustomed to the “button-ology” of moving around to intended “VR destinations.”

The basis of this new VR application concept is that one person would be able to “navigate” the VR encounter that is experienced simultaneously by multiple participants. Participants would not need to “drive” menus or navigate their VR equipment to the destination; they would just pay attention and partake in the experience. The chosen multi-user experience, referenced as a VR Educational Exploration (VReX) would consist of a continuum of pre-determined places, times, and interactions with pre-determined people (either controlled by other live users or controlled by artificial intelligence). Pre-existing VR applications that all users experience simultaneously would likewise be an option. The given VReX would be navigated by one person (the VReX navigator) on behalf of all participants, meanwhile all participants – students & facilitators – would be placed into the same scenario simultaneously.

As a part of the VReX experience, all participants would be able to, at minimum, communicate verbally with each other, while their first-person view of the common environment would infinitely vary based upon the participant’s own head and body tracking sensors. For certain experiences, each of the participants would also be able to see a live, avatar representations of his/her fellow participants enabling a social learning experience. Considering that multiple platforms already exist that utilize social VR, the ability to control this for multiple users at once is a realistic near-term goal.

While the VReX navigator would control the technology and the environment that participants experience, there could also be a VReX subject matter facilitator (or instructor) who moderates the interaction, gives instructions, presents guided discussion, and asks questions appropriate to intended learning outcomes. (In some instances, a highly skilled instructor may be able to control the VReX navigator role simultaneously with the VReX facilitator role.)

During this early stage of the VR technology lifecycle, having a multi-participant VReX application would enable those who are already familiar with VR (or have well-grounded "VR legs") to be able to expand the experience of using VR to many others who do not yet have their "VR legs." This model would enable a "train the trainer" leveraged capability that could gradually expand the number of VR-fluent members of the learning community.

Recommendations for Future Research

The SOC/EFLT Collaboration Agreement. During the course of this research a real-world concrete deliverable that was developed is known as the SOC/EFLT collaborative agreement. This agreement provides a framework for future collaboration on research, learning, and scholarly publication efforts between the Air University's Squadron Officer College and Auburn University College of Education's Department of Education Foundations, Leadership and Technology. The primary researcher of this dissertation suggests that continued operation under the SOC/EFLT collaborative agreement would be in the best interests of both organizations. Likewise, other collaborative relationships between Air University and Auburn University should continue to be encouraged. Resulting published research deliverables from such agreements may also be useful for others who plan to engage in VR endeavors in adult/higher/military education settings.

The ITEQ Instrument. The ITEQ instrument can also serve as a useful baseline instrument for developing future questionnaires specifically-designed to engage in stakeholder involvement in introducing new technologies within other Air University education programs. Research on expanding the ITEQ or conducting validation studies on the ITEQ would be of value.

Repeat the study at a son-military educational institution. While the results provided from the present study present a valuable baseline of understanding on VR in Education that may be applicable throughout higher education, if a non-military educational body would conduct a similar study, there are other factors that could be analyzed and reported upon. A key example of such an area is that of accessibility. Within the civilian higher education arena, there are many more stakeholders with disabilities available to provide input from those perspectives. Perhaps some of the best value-added to humanity by VR could be enabling learning experiences to those who otherwise would be unable.

Conclusion

The prospects for expanded use of VR and AR worldwide are strong and undoubtedly improvements will develop in a broad array of life endeavors as a result. However, as of the writing of this dissertation, in general, the greater world of education has not yet become a leader on the VR world stage. This could likely be from the tradition within academia of waiting until the critical mass is involved in a piece of technology before boldly moving in. Likewise, the absence of deep budgets in education is another factor that discourages ambitious explorations in Ed Tech. Given this reality, the concept of establishing VR in Education “Technology Incubators” with robust funding for a narrow focus of exploratory activities would be a good balance between exploring the technology for “game changing” potential while simultaneously not risking loss of productivity in critical educational outcomes.

The US Air Force was born of innovation. Airpower pioneers such as General Billy Mitchell who advocated for the establishment of a separate Air Force in the early-mid 20th century did so by challenging the status quo and taking advantage of new possibilities presented to humankind based on new technology. In the 1920-1440 era, the Air Corps Tactical School became the birthplace for doctrine on how to use aviation as an instrument of national security. The Air Corps Tactical School, from 1931-1940, pursued that noble cause of innovation with technology in the very building and office that this paragraph is being written in. Still today, the culture and traditions of the Air Corps Tactical School are carried on within its descendent organization, the Air University. Supported by the ideas communicated from a population of Air Force stakeholders included in the present study, perhaps the Air University, in collaboration with multiple other educational institutions and technology industry partners, will forge ahead as a leader in innovation for experiential learning using VR. This noble challenge is one that is sure to have an impact beyond just the world of education, but within the broader scope of national security. The maxim to urge progress in this new arena can best be expressed by the Air Corps Tactical School motto: *Prōfĭcīmus Mōré Irrĕtĕntī* – "We Make Progress Unhindered by Custom."

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Appendix A

Auburn University Institutional Review Board Approval

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUMAN SUBJECTS

RESEARCH PROTOCOL REVIEW FORM

FULL BOARD or EXPEDITED

For Information or help contact THE OFFICE OF RESEARCH COMPLIANCE (ORC), 115 Ramsay Hall, Auburn University
Phone: 334-844-5966 e-mail: IRBAdmin@auburn.edu Web Address: http://www.auburn.edu/research/vpr/ohs/index.htm

Revised 2.1.2014 **Submit completed form to IRBsubmit@auburn.edu or 115 Ramsay Hall, Auburn University 36849.**

Form must be populated using Adobe Acrobat / Pro 9 or greater standalone program (do not fill out in browser). Hand written forms will not be accepted.

1. PROPOSED START DATE of STUDY: July 11, 2016

PROPOSED REVIEW CATEGORY (Check one): ☐ FULL BOARD ☑ EXPEDITED

SUBMISSION STATUS (Check one): ☐ NEW ☑ REVISIONS (to address IRB Review Comments)

2. PROJECT TITLE: Virtual Reality (VR) in Higher Education: a Case Study at the Air University's Squadron Officer College (Protocol #16-224, Millican)

3.

Tony L. Millican	Graduate Student	EFLT - College of Ed.	tlm0022@auburn.edu
PRINCIPAL INVESTIGATOR	TITLE	DEPT	AU E-MAIL
149 River Forest Ct. Millbrook AL 36054		(334) 301-4325	tony.millican@gmail.com
MAILING ADDRESS		PHONE	ALTERNATE E-MAIL

4. FUNDING SUPPORT: ☑ N/A ☐ Internal ☐ External Agency: ____________ ☐ Pending ☐ Received

For federal funding, list agency and grant number (if available). ____________

5a. List any contractors, sub-contractors, other entities associated with this project:

N/A

b. List any other IRBs associated with this project (including Reviewed, Deferred, Determination, etc.):

US Air Force: Air University; POC: Dr. Particia Maggard; phone: 334-953-8046; email: patricia.maggard@us.af.mil

PROTOCOL PACKET CHECKLIST

All protocols must include the following items:

- ☑ Research Protocol Review Form (All signatures included and all sections completed)
  (Examples of appended documents are found on the OHSR website: http://www.auburn.edu/research/vpr/ohs/sample.htm)
- ☑ CITI Training Certificates for all Key Personnel.
- ☑ Consent Form or Information Letter and any Releases (audio, video or photo) that the participant will sign.
- ☑ Appendix A, "Reference List"
- ☑ Appendix B if e-mails, flyers, advertisements, generalized announcements or scripts, etc., are used to recruit participants.
- ☑ Appendix C if data collection sheets, surveys, tests, other recording instruments, interview scripts, etc. will be used for data collection. Be sure to attach them in the order in which they are listed in # 13c.
- ☒ Appendix D if you will be using a debriefing form or include emergency plans/procedures and medical referral lists (A referral list may be attached to the consent document). (Not used)
- ☑ Appendix E if research is being conducted at sites other than Auburn University or in cooperation with other entities. A permission letter from the site / program director must be included indicating their cooperation or involvement in the project. NOTE: If the proposed research is a multi-site project, involving investigators or participants at other academic institutions, hospitals or private research organizations, a letter of IRB approval from each entity is required prior to initiating the project.
- ☒ Appendix F - Written evidence of acceptance by the host country if research is conducted outside the United States. (N/A)

FOR ORC OFFICE USE ONLY

DATE RECEIVED IN ORC: ____________ by ____________ PROTOCOL #
DATE OF IRB REVIEW: ____________ by ____________ APPROVAL CATE
DATE OF IRB APPROVAL: ____________ by ____________ INTERVAL FOR CO
COMMENTS:

The Auburn University Institutional Review Board has approved this Document for use from 07/22/2016 to 07/21/2017
Protocol # 16-224 EP 1607

6. **GENERAL RESEARCH PROJECT CHARACTERISTICS**

6A. Research Methodology

Please check all descriptors that best apply to the research methodology.

Data Source(s): ☑ New Data ☑ Existing Data

Will recorded data directly or indirectly identify participants?
☑ Yes ☐ No

Data collection will involve the use of:

- Educational Tests (cognitive diagnostic, aptitude, etc.)
- ✓ Interview
- Observation
- Location or Tracking Measures
- Physical / Physiological Measures or Specimens (see Section 6E.)
- Surveys / Questionnaires
- Internet / Electronic
- ✓ Audio
- ✓ Video
- Photos
- Digital Images
- Private records or files
- ✓ Other: Focus Groups. (Note: Audio & Video limited exclusively to recording the interviews & focus groups respectively and will only be used to produce written transcripts of those sessions.)

6B. Participant Information

Please check all descriptors that apply to the target population.
☑ Males ☑ Females ☐ AU students

Vulnerable Populations
☐ Pregnant Women/Fetuses ☐ Prisoners ☐ Institutionalized
☐ Children and/or Adolescents (under age 19 in AL)

Persons with:

☐ Economic Disadvantages ☐ Physical Disabilities
☐ Educational Disadvantages ☐ Intellectual Disabilities

Do you plan to compensate your participants? ☐ Yes ☑ No

6C. Risks to Participants

Please identify all risks that participants might encounter in this research.

☑ Breach of Confidentiality* ☐ Coercion
☐ Deception ☐ Physical
☐ Psychological ☐ Social
☐ None
☐ Other:

*Note that if the investigator is using or accessing confidential or identifiable data, breach of confidentiality is always a risk.

6D. Corresponding Approval/Oversight

- Do you need IBC Approval for this study?
  ☐ Yes ☑ No

  If yes, BUA # ____________________ Expiration date ____________________

- Do you need IACUC Approval for this study?
  ☐ Yes ☑ No

  If yes, PRN # ____________________ Expiration date ____________________

- Does this study involve the Auburn University MRI Center?
  ☐ Yes ☑ No

  Which MRI(s) will be used for this project? (Check all that apply)
  ☐ 3T ☐ 7T

  Does any portion of this project require review by the MRI Safety Advisory Council?
  ☐ Yes ☑ No

  Signature of MRI Center Representative: ____________________
  Required for all projects involving the AU MRI Center

  Appropriate MRI Center Representatives:
  Dr. Thomas S. Denney, Director AU MRI Center
  Dr. Ron Beyers, MR Safety Officer

7. PROJECT ASSURANCES Virtual Reality (VR) in Higher Education: a Case Study at the Air University's Squadron Officer College (Protocol #16-224, Millican)

A. PRINCIPAL INVESTIGATOR'S ASSSURANCES

1. I certify that all information provided in this application is complete and correct.
2. I understand that, as Principal Investigator, I have ultimate responsibility for the conduct of this study, the ethical performance this project, the protection of the rights and welfare of human subjects, and strict adherence to any stipulations imposed by the Auburn University IRB.
3. I certify that all individuals involved with the conduct of this project are qualified to carry out their specified roles and responsibilities and are in compliance with Auburn University policies regarding the collection and analysis of the research data.
4. I agree to comply with all Auburn policies and procedures, as well as with all applicable Federal, state, and local laws regarding the protection of human subjects, including, but not limited to the following:
   a. Conducting the project by qualified personnel according to the approved protocol
   b. Implementing no changes in the approved protocol or consent form without prior approval from the Office of Research Compliance
   c. Obtaining the legally effective informed consent from each participant or their legally responsible representative prior to their participation in this project using only the currently approved, stamped consent form
   d. Promptly reporting significant adverse events and/or effects to the Office of Research Compliance in writing within 5 working days of the occurrence.
5. If I will be unavailable to direct this research personally, I will arrange for a co-investigator to assume direct responsibility in my absence. This person has been named as co-investigator in this application, or I will advise ORC, by letter, in advance of such arrangements.
6. I agree to conduct this study only during the period approved by the Auburn University IRB.
7. I will prepare and submit a renewal request and supply all supporting documents to the Office of Research Compliance before the approval period has expired if it is necessary to continue the research project beyond the time period approved by the Auburn University IRB.
8. I will prepare and submit a final report upon completion of this research project.

My signature indicates that I have read, understand and agree to conduct this research project in accordance with the assurances listed above.

Tony L. Millican	MILLICAN.TONY.L.10654 25722	24 June 2016
Printed name of Principal Investigator	**Principal Investigator's Signature**	**Date**

B. FACULTY ADVISOR/SPONSOR'S ASSURANCES

1. I have read the protocol submitted for this project for content, clarity, and methodology.
2. By my signature as faculty advisor/sponsor on this research application, I certify that the student or guest investigator is knowledgeable about the regulations and policies governing research with human subjects and has sufficient training and experience to conduct this particular study in accord with the approved protocol.
3. I agree to meet with the investigator on a regular basis to monitor study progress. Should problems arise during the course of the study, I agree to be available, personally, to supervise the investigator in solving them.
4. I assure that the investigator will promptly report significant incidents and/or adverse events and/or effects to the ORC in writing within 5 working days of the occurrence.
5. If I will be unavailable, I will arrange for an alternate faculty sponsor to assume responsibility during my absence, and I will advise the ORC by letter of such arrangements. If the investigator is unable to fulfill requirements for submission of renewals, modifications or the final report, I will assume that responsibility.

Frances K. Kochan	Frances K. Kochan	June 26, 2016
Printed name of Faculty Advisor / Sponsor	**Faculty Advisor's Signature**	**Date**

C. DEPARTMENT HEAD'S ASSSURANCE

By my signature as department head, I certify that I will cooperate with the administration in the application and enforcement of all Auburn University policies and procedures, as well as all applicable federal, state, and local laws regarding the protection and ethical treatment of human participants by researchers in my department.

Sherida Downer	Sherida Downer	6/26/16
Printed name of Department Head	**Department Head's Signature**	**Date**

8. **PROJECT OVERVIEW: Prepare an abstract that includes:**
(350 word maximum, in language understandable to someone who is not familiar with your area of study)

a) **A summary of relevant research findings leading to this research proposal:**
(Cite sources; include a "Reference List" as Appendix A.)

b) **A brief description of the methodology, including design, population, and variables of interest**

a.) For generations, educational theorists have professed that deep learning occurs best when learners actively participate or have an experience as part of learning (Friedman, 2005; Kolb, 2014, Weigel, 2002). Given recent advances in consumer technology, Virtual and Augmented Reality technologies present new opportunities for learners to engage with subject matter visually, audibly, and tactilely in "first-person" and to have a unique experience as part of the learning process. (Hale & Stanney, 2015; Siddique, Ling, Roberson, & Zu, 2013)

U.S. Air Force senior leadership has expressed a strong emphasis toward investigating new technologies that have potential application in areas such as the PME Environment (James & Welsh, 2015). As evidenced by the Air University Commander's recent use of Virtual Reality at Corona (to demonstrate its potential application in PME) to the Chief of Staff, the Secretary of the Air Force and top USAF leadership, VR has arrived at the front-and-center position for the need to be researched. The graduate PME community (and higher education at-large) have an immediate need to be better informed on the nature of Virtual and Augmented Reality technologies in order to assess opportunities for investing in these technologies as strategic assets.

b.) This research is an exploratory intrinsic case study using multiple qualitative data sources. Pre-existing data will include Squadron Officer College (SOC) centrally-developed lesson plans as well as data from SOC's internally-administered open-ended questionnaire known as the the Immersive Technology in Education Questionnaire (ITEQ.) Beyond pre-existing data, semi-structured interviews and focus groups will be conducted. Open coding of the pre-existing data sources will be conducted and analyzed to inform the baseline protocols for the semi-structured interviews and focus groups. Ten 20-45-minute audio recorded semi-structured interviews & two 60-90-minute video recorded focus groups will be conducted with key SOC Stakeholders. Selection of subjects will be made using a purposeful sample of SOC Key Stakeholders with identification of participants based on key findings from analysis of pre-existing data and using advice of the SOC key informant (Dr. Fil Arenas). All methods used will address each research question.

NOTE: The PI and the SOC Key Informant are NOT (nor ever have been/nor anticipated in the future to be) in the chain-of-command of any of the participants involved in the interviews or focus groups. Further, the PI and SOC Key Informant pledge confidentiality to all participants to never reveal individual identities in regard to their participating (or others not participating) in the study. These assurances, combined with a strong culture of academic non-attribution within SOC, serve to ensure honest, open participation by subjects and likewise serve to minimize likelihood of confidentiality breach.

9. **PURPOSE.**

a. **Clearly state the purpose of this project and all research questions, or aims.**

The purpose of this study is to inform the Air University policy process, curriculum development efforts, and instructional practices on strategies to enhance and support the integration of VR into the graduate Professional Military Education (PME) learning environment. The study seeks to determine the elements that would be potential success factors, opportunities, benefits, challenges, detriments and means to overcome challenges/detriments for integrating VR into the SOC learning environment and to synthesize a compendium of practicable VR applications with potential to enhance learning outcomes in graduate PME. The study addresses three main questions:
1. What do SOC Stakeholders identify as the potential success factors, opportunities, and benefits of integrating VR as a tool in the learning process?
2. What do SOC Stakeholders identify as the potential challenges or detriments of integrating VR as a tool in the learning process (and possible strategies to overcome)?
3. What VR content would have the most impact on SOC student learning?

b. **How will the results of this project be used? (e.g., Presentation? Publication? Thesis? Dissertation?)**

Results of the project will be used as the basis of the PI's doctoral dissertation and may subsequently be used as the basis of professional publications and/or presentations.

10. KEY PERSONNEL. Describe responsibilities. Include information on research training or certifications related to this project. CITI is required. Be as specific as possible. (Include additional personnel in an attachment.) *All key personnel must attach CITI certificates of completion.*

Principle Investigator Tony L. Millican Title: Graduate Student E-mail address tlm0022@auburn.edu

Dept / Affiliation: EFLT - College of Ed.

Roles / Responsibilities:

Producing all phases of the dissertation: Collecting Data; Analyzing Data; Interpreting Findings; Reporting Results

Individual: Dr. Frances K. Kochan Title: Prof. Emerita E-mail address kochafr@auburn.edu

Dept / Affiliation: EFLT - College of Education

Roles / Responsibilities:

Dissertation Committee Chair.

Individual: Dr. Jung Won Hur Title: Assoc. Prof. E-mail address jzh0011@auburn.edu

Dept / Affiliation: EFLT - College of Education

Roles / Responsibilities:

Dissertation Committee Co-chair.

Individual: Ellen Reames Title: Assoc. Prof. E-mail address reamseh@auburn.edu

Dept / Affiliation: EFLT - College of Education

Roles / Responsibilities:

Committee Member.

Individual: Linda Searby Title: Assoc. Prof E-mail address ljs0007@auburn.edu

Dept / Affiliation:

Roles / Responsibilities:

Committee Member.

Individual: Fil Arenas Title: Assoc. Prof E-mail address filomeno.arenas@us.af.mil

Dept / Affiliation: USAF Squadron Officer College (SOC)

Roles / Responsibilities:

1. Committee Member.
2. SOC project lead for the SOC-internal survey called the Immersive Technology in Education Questionnaire (ITEQ). the results of the instrument (completed in Q1 2016) will be used as pre-existing data in the present study.
3. Advise PI on the identification & selection of the purposeful sample of participants in the interviews and focus groups.

11. LOCATION OF RESEARCH. List all locations where data collection will take place. (School systems, organizations, businesses, buildings and room numbers, servers for web surveys, etc.) Be as specific as possible. Attach permission letters in Appendix E. (See sample letters at http://www.auburn.edu/research/vpr/ohs/sample.htm)

U.S. Air Force Squadron Officer College, 225 Chennault Circle, Montgomery, AL 36112

12. PARTICIPANTS.

a. Describe the participant population you have chosen for this project including inclusion or exclusion criteria for participant selection.

☑ Check here if using existing data, describe the population from whom data was collected, & include the # of data files.

The study population will consist of adult key Stakeholders from the USAF Squadron Officer College (SOC) who previously participated in the "VR in Education Challenge," an internal SOC-led program whereby SOC Stakeholders engaged in informal self-guided inquiry on VR in Education, used VR equipment hands-on at SOC's VR lab to gain more depth of understanding and provided written inputs via questionnaire. The population of participants comes from the broader body of Stakeholders including active duty military instructors, civilian professors, support staff, organizational leaders and external university officials.

b. Describe, step-by-step, in layman's terms, all procedures you will use to recruit participants. *Include in Appendix B a copy of all e-mails, flyers, advertisements, recruiting scripts, invitations, etc., that will be used to invite people to participate.* *(See sample documents at http://www.auburn.edu/research/vpr/ohs/sample.htm.)*

1. Data from the ITEQ will be open-coded and analyzed to determine which SOC curriculum areas are identified by stakeholders to be most prime for application of VR as an impactful learning tool and/or which SOC staff support agencies would play a key part in the process of integrating VR technology into the learning process.
2. SOC Key Informant will provide PI with list of participants on each curriculum area committee and list of personnel assigned to staff support agencies. Key Informant will further advise PI on identifying individuals within curriculum area committees and staff support agencies to invite as participants in semi-structured interviews and focus groups.
3. Key Informant will send email invitation to those identified as potential participants. Invitation will emphasize that participation is completely voluntary and that confidentiality of participant responses will be preserved. Key Informant will connect participants with PI to arrange time & place for the research activities (Copies of invitation emails are included at Appendix B.)

c. What is the minimum number of participants you need to validate the study? 20

How many participants do you expect to recruit? 26

Is there a limit on the number of participants you will include in the study? ☐ No ☑ Yes – the # is 26

d. Describe the type, amount and method of compensation and/or incentives for participants.

(If no compensation will be given, check here: ☑)

Select the type of compensation: ☐ Monetary ☐ Incentives

☐ Raffle or Drawing incentive (Include the chances of winning.)
☐ Extra Credit (State the value)
☐ Other

Description:

13. PROJECT DESIGN & METHODS.

a. Describe, step-by-step, all procedures and methods that will be used to consent participants. If a waiver is being requested, check each waiver you are requesting, describe how the project meets the criteria for the waiver.

- ☐ Waiver of Consent (including using existing data)
- ☐ Waiver of Documentation of Consent (use of Information Letter)
- ☐ Waiver of Parental Permission (for college students)

1. Obtain permission to conduct study from SOC Commander & Air University Academic Affairs
2. Contact, via email from Key Informant, stakeholders identified as primary sources for interviews & focus groups
3. Introduce the researcher, study's purpose, & reason for selecting subjects to participate
4. Advise that participation is voluntary and that confidentially will be ensured
5. Informed consent forms signed by all participants pior to each of the 10 interviews & 2 8-person focus groups

b. Describe the research design and methods you will use to address your purpose. Include a clear description of when, where and how you will collect all data for this project. Include specific information about the participants' time and effort commitment. (*NOTE: Use language that would be understandable to someone who is not familiar with your area of study. Without a complete description of all procedures, the Auburn University IRB will not be able to review this protocol. If additional space is needed for this section, save the information as a .PDF file and insert after page 7 of this form.*)

The purpose of this study is to inform the Air University policy process, curriculum development efforts, and instructional practices on strategies to enhance and support the integration of VR into the graduate Professional Military Education (PME) learning environment. The study seeks to determine the elements that would be potential success factors, opportunities, benefits, challenges, detriments and means to overcome challenges/detriments for integrating VR into the SOC learning environment and to synthesize a compendium of practicable VR applications with potential to enhance learning outcomes in graduate PME.

The study seeks to fulfill this purpose by exploring SOC Stakeholders' qualitative ideas on the subject of integrating VR as a learning tool into the curriculum and to produce a synthesis report on the findings. Using the ATLAS.ti qualitative data ananlysis software, the PI will perform analysis on the pre-existing SOC internally-administered ITEQ data. From the data analysis, the researcher will refine the baseline interview and focus group protocols in accordance with significant findings from the questionnaire data.

The researcher proposes to administer 10 20-45-minute audio recorded and transcribed semi-structured interviews, and 2 60-90-minute video recorded and transcribed focus groups of 8 participants each from among the population of SOC Stakeholders. Transcripts of the interviews and focus groups will be produced as electronic documents using the online transcription service, Rev.com. Transcripts will be open-coded and analyzed using ATLAS.ti qualitative data analysis software.

The researcher will then synthesize analyses from all sources (pre-existing questionnaire data, interviews, and focus groups) along with analysis of other pre-existing data (SOC lesson plans) into a final report to inform SOC curriculum development efforts and to include in the results chapter of the researcher's doctoral dissertation.

Participants will be given leeway to identify a convenient time to conduct interviews, and for the two focus groups, both will be conducted in concert with the Squadron Officer College master calendar in order to avoid conflicts with times that SOC faculty and staff are expected to be actively practicing their primary duties. The location for all interviews and focus groups will be in office and/or classroom spaces inside the Squadron Officer College building. Since audio recordings will be made of interviews, and video recordings will be made of focus groups, the informed consent form signed by all participants will include their acknowledgement of the fact that the session will be recorded strictly for the purpose of producing transcripts. Likewise, the informed consent form will acknowledge that participants are aware that (in accordance with the Air University policy on non-attribution) the PI and Key Informant have vowed strict confidentiality to not connect any inputs provided back to the originator.

13. PROJECT DESIGN & METHODS. *Continued*

c. List all data collection instruments used in this project, in the order they appear in Appendix C.
(e.g., surveys and questionnaires in the format that will be presented to participants, educational tests, data collection sheets, interview questions, audio/video taping methods etc.)

1. Semi-structured Interview Baseline Protocol (audio taped in order to subsequently produce a written transcript)
2. Focus Group Baseline Protocol (video taped in order to subsequently produce a written transcript)

d. Data analysis: Explain how the data will be analyzed.

The researcher will employ open-coding techniques using the ATLAS.ti qualitative data analysis software. Codes and resulting analysis will be framed around the fundamental research questions.

14. RISKS & DISCOMFORTS: List and describe all of the risks that participants might encounter in this research. *If you are using deception in this study, please justify the use of deception and be sure to attach a copy of the debriefing form you plan to use in Appendix D.* (Examples of possible risks are in section #6D on page 2)

No discomforts are to be anticipated.

Because focus group and interview data are being used, as always with these methods, breach of confidentiality is a potential risk.

15. PRECAUTIONS. Identify and describe all precautions you have taken to eliminate or reduce risks as listed in #14. If the participants can be classified as a "vulnerable" population please describe additional safeguards that you will use to assure the ethical treatment of these individuals. *Provide a copy of any emergency plans/procedures and medical referral lists in Appendix D. (Samples can be found online at http://www.auburn.edu/research/vpr/ohs/sample.htm#precautions)*

The risk of breaching confidentiality will be minimized by not using individuals' names in the final report, but rather using generic identifiers (e.g. "Communications Curriculum Committee Member" or "Athletics Staff Member") as well as using pseudonymous names whenever the mode of discussion requires using a name (e.g. "Mister Orange," or "Captain Blue"). Further, written transcripts will only refer to interviewees by pseudonymous identities. Only the key informant, the PI, and the participants will ever be aware of the actual identities of the individuals being interviewed. Focus Group participants will be reminded of the Air Force policy on academic non-attribution and advised to avoid disclosing identities and comments of fellow participants after the session has completed.

NOTE: The PI and the SOC Key Informant are NOT (nor ever have been/nor anticipated in the future to be) in the chain-of-command of any of the participants involved in the interviews or focus groups. Further, the PI and SOC Key Informant pledge confidentiality to all participants to never reveal individual identities in regard to their participating (or others not participating) in the study. These assurances, combined with a strong culture of academic non-attribution within SOC, serve to ensure honest, open participation by subjects and likewise serve to minimize likelihood of confidentiality breach.

If using the Internet or other electronic means to collect data, what confidentiality or security precautions are in place to protect (or not collect) identifiable data? Include protections used during both the collection and transfer of data.

Electronic means are not used to collect data; pre-existing data that has been electronically collected will be used. The pre-existing data records are not specifically connected to individual participants. The only individual with the ability to indirectly connect participants with those data is the SOC Key Informant (in his capacity of SOC project lead for the SOC-internal ITEQ survey.) (His oath of confidentialty to participants occurred previous to the present research.)

With regard to protection of the electronic documents containing the transcribed interviews and focus groups, the PI will maintain a single master copy of those documents on CD-ROM for a period of three years upon completion of the research.

16. BENEFITS.

a. List all realistic direct benefits participants can expect by participating in this specific study.
(Do not include "compensation" listed in #12d.) Check here if there are no direct benefits to participants. ☐

Participants will not receive any direct benefits from participating in the study.

b. List all realistic benefits for the general population that may be generated from this study.

Benefits will be to the Air Force graduate PME population and the graduate-level education populations at-large. By developing a better understanding of applying VR to Education, the accrued benefit will be to advance the use of these technologies in improving educational outcomes.

17. PROTECTION OF DATA.

a. Data are collected:

☐ Anonymously with no direct or indirect coding, link, or awareness of who participated in the study (Skip to e)

☑ Confidentially, but without a link of participant's data to any identifying information (collected as "confidential" but recorded and analyzed as "anonymous") (Skip to e)

☐ Confidentially with collection and protection of linkages to identifiable information

b. If data are collected with identifiers or as coded or linked to identifying information, describe the identifiers collected and how they are linked to the participant's data.

c. Justify your need to code participants' data or link the data with identifying information.

d. Describe how and where identifying data and/or code lists will be stored. (Building, room number?) Describe how the location where data is stored will be secured in your absence. For electronic data, describe security. If applicable, state specifically where any IRB-approved and participant-signed consent documents will be kept on campus for 3 years after the study ends.

e. Describe how and where the data will be stored (e.g., hard copy, audio cassette, electronic data, etc.), and how the location where data is stored is separated from identifying data and will be secured in your absence. For electronic data, describe security

The principal investigator will keep the participant-signed consent forms plus all archived working files, analysis files, and any other pertinent electronic data (including electronically recorded audio and video files) on a CD-ROM in a locked box for three years in his office at the School of Graduate Professional Military Education, Maxwell AFB, AL. The School is on a secure military base inside a facility that is either occupied by staff or locked at all times. All original electronic files beyond the archive versions on CD-ROM will be deleted.

f. Who will have access to participants' data?
(The faculty advisor should have full access and be able to produce the data in the case of a federal or institutional audit.)

Access to the archived data will be provided to the faculty advisor at any time upon request. In the event of the demise of the PI, the SOC Key Informant (Dr. Fil Arenas) will also be provided access to the archived data.

g. When is the latest date that identifying information or links will be retained and how will that information or links be destroyed? (Check here if only anonymous data will be retained ☐)

The archived data will be destroyed three years after completion of the research study.

Appendix B

IRB Modification Approval

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUMAN SUBJECTS

REQUEST for MODIFICATION

For help, contact: **THE OFFICE OF RESEARCH COMPLIANCE (ORC)**, 115 Ramsay Hall, Auburn University
Phone: 334-844-5966 **e-mail:** IRBAdmin@auburn.edu **Web Address:** http://www.auburn.edu/research/vpr/ohs

Revised 2.1.2014 **Submit completed form to IRBsubmit@auburn.edu or 115 Ramsay Hall, Auburn University 36849.**

Form must be populated using Adobe Acrobat / Pro 9 or greater standalone program (do not fill out in browser). Hand written forms will not be accepted.

1. **Protocol Number:** 16-224 EP 1607
2. **Current IRB Approval Dates: From:** 07/22/2016 **To:** 07/21/2017
3. **Project Title:** Virtual Reality in Higher Education: A Case Study at the Air University's Squadron Officer College
4.

Tony L. Millican	PhD Student	EFLT	334-301-4325	tlm0022@auburn.edu
Principal Investigator	**Title**	**Department**	**Phone**	**AU E-Mail** (primary)
Tony L. Millican		149 River Forest Ct, Millbrook AL		tony.millican@gmail.com
PI Signature		**Mailing Address**		**Alternate E-Mail**
Dr. Frances Kochan	Frances K. Kochan	EFLT	334-332-3618	kochafr@auburn.edu
Faculty Advisor	**FA Signature**	**Department**	**Phone**	**AU E-Mail**

Name of Current Department Head: Sherida Downer **AU E-Mail:** downesh@auburn.edu

5. **Current External Funding Agency and Grant number:** N/A
6. **a. List any contractors, sub-contractors, other entities associated with this project:**

   AFMSA/SGE-C; Megan McFarland; ph: 703-681-8056; email: megan.e.mcfarland.ctr@mail.mil

   b. List any other IRBs associated with this project:
7. **Nature of change in protocol: (Mark all that apply)**

- ☐ **Change in Key Personnel** (attach CITI forms for new personnel)
- ☐ **Change in Sites** (attach permission forms for new sites)
- ☐ **Change in methods for data storage/protection or location of data/consent documents**
- ☐ **Change in project purpose or questions**
- ☑ **Change in population or recruitment** (attach new or revised recruitment materials as needed)
- ☑ **Change in consent procedures** (attach new or revised consent documents as needed)
- ☐ **Change in data collection methods or procedures** (attach new data collection forms as needed)
- ☐ **Other (explain):**

FOR ORC OFFICE USE ONLY

DATE RECEIVED IN ORC: by
DATE OF IRB REVIEW: by
DATE OF IRB APPROVAL: by
COMMENTS:
MODIFICAT
PROTOCOL
MODIFICAT
INTERVAL F

The Auburn University Institutional Review Board has approved this Document for use from 10/11/2016 to 07/21/2017
Protocol # 16-224 EP 1607

1 of 2

8. Briefly list *(numbered or bulleted)* **the activities that have occurred up to this point, particularly those that involved participants**

-- In 1st quarter 2016, Squadron Officer College (SOC) conducted an internal survey of faculty using the ITEQ instrument - an exempt activity per Air University - led by Dr. Fil Arenas of SOC
-- In July 2016, Auburn IRB approved protocol 16-224 which included ITEQ data as a pre-existing data source and identified Dr. Fil Arenas on dissertation committee and involved in the research
-- During Component-Level Administrative Review (CLAR), Sept 23, 2016, Headquarters Air Force AFMSA/SGE-C provided 3 items for the researcher to address that require IRB coordination/approval before research may proceed (per Air Force requirements)

9. For each item marked in Question #7, describe the requested changes to your research protocol, with an explanation and/or rationale for each. (*Additional pages may be attached if needed to provide a complete response.)*

Specific Items to be addressed include:

1. Since the exempt ITEQ data contained private identifiable information from respondents, and since Dr. Arenas is subsequently involved in the non-exempt portion of the research, AFMSA/SGE-C requires the researcher to identify ITEQ participants as human subjects in the IRB protocol. AFMSA/SGE-C further advised to request a waiver of informed consent for those subjects under 32 CFR 219.116(d)/ 45 CFR 46.116(d). Proposed waiver of informed consent for ITEQ participants is included at attachment 1.

2. AFMSA/SGE-C recommend that the last line in the recruitment emails (i.e., Thanks in advance for your participation in the research!) be removed so that participation in the research is not assumed. Revised versions of recruitment emails (removing that line) are included at attachments 2 & 3.

3. AFMSA/SGE-C recommended to include a statement in the informed consent documents noting that the study is being supported by the DoD and that DoD may access records to ensure subject safety. Revised version of the informed consent document (incorporating the one suggested statement) is included at attachment 4.

Copy of previously-approved IRB protocol package is included at attachment 5.

10. Identify any changes in the anticipated risks and / or benefits to the participants.

No changes in anticipated risks and/or benefits anticipated.

11. Identify any changes in the safeguards or precautions that will be used to address anticipated risks.

No changes in safeguards or precautions need to be made.

12. Attach a copy of all "stamped" IRB-approved documents you are currently using. *(information letters, consents, flyers, etc.)*

Appendix C

Air Force Human Research Protection Official Approval

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

2 6 OCT [illegible]

MEMORANDUM FOR HQ AU/A3A

FROM: AFMSA/SGE-C
AF Research Oversight & Compliance Division
7700 Arlington Blvd. Ste. 5151
Falls Church, VA 22042-5151

SUBJECT: Human Research Protection Official (HRPO) Review of **FSG20160024H**

References: (a) 32 CFR 219, *Protection of Human Subjects*
(b) 10 USC 980, *Limitation on Use of Humans as Experimental Subjects*
(c) DoDI3216.02_AFI40-402, *Protection of Human Subjects and Adherence to Ethical Standards in Air Force Supported Research*

In accordance with Reference (c), this study has successfully completed review from AFSMA/SGE-C and obtained CLAR and Human Research Protection Official (HRPO) approval for the following minimal risk study:

FSG20160024H, "Virtual Reality (VR) in Higher Education".

Please ensure this research is conducted in compliance with the References, including Reference (c), as it pertains to submission of continuing review reports, proper maintenance of records, and the application of written informed consent to all study participants, as required by the IRB.

Contact AFMSA/SGE-C at usaf.pentagon.af-sg.mbx.afmsa-sge-c@mail.mil to discuss any substantive change to this activity prior to implementation to ensure it does not impact the determination herein or compliance with the above References.

Please refer to the Terms of Air Force HRPO Approval (attached) regarding reporting requirements and responsibilities of the Principal Investigator to the HRPO. Failure to comply could result in suspension of funding.

Peter Marshall

PETER MARSHALL, CIP
Program Manager, AF Research Oversight & Compliance Division

Attachment(s):
Terms of AF HRPO Approval

TERMS OF AIR FORCE HUMAN RESEARCH PROTECTION OFFICIAL (HRPO) APPROVAL

1. By virtue of the Air Force (AF) support (see definition in DoDI 3216.02_AFI 40-402) provided to the non-Department of Defense (DoD) institution performing the activity identified herein, this activity must comply with all applicable federal, DoD, and AF human research protection requirements. In addition to the requirements identified in conducting non-DoD institution's Federalwide Assurance, compliance with the following laws, regulations, and guidance is required:

- Title 32 Code of Federal Regulations Part 219 (32 CFR 219), Department of Defense Regulations, "Protection of Human Subjects"
- Title 45 Code of Federal Regulations Part 46, (45 CFR 46) Department of Health and Human Services Regulations, "Protection of Human Subjects," Subparts B, C, D, and E as made applicable by DoD Instruction (DoDI) 3216.02
- Title 21 Code of Federal Regulations 50, 56, 312, and 812, Food and Drug Administration (FDA) Regulations
- DoDI 3216.02, "Protection of Human Subjects and Adherence to Ethical Standards in DoD-supported Research"
- Title 10 United States Code Section 980 (10 USC 980), "Limitation on Use of Humans as Experimental Subjects"
- DoDI 3210.7, "Research Integrity and Misconduct"
- DoDI 6200.02, "Application of Food and Drug Administration (FDA) Rules to Department of Defense Force Health Protection Programs"
- DoDI 3216.02_AFI 40-402, "Protection of Human Subjects and Adherence to Ethical Standards in Air Force Supported Research"

2. Below is a select list of requirements from the regulations and guidance listed above. The non-DoD institution should communicate with the supporting AF institution to ensure compliance.

- Ensure all DoD supported activities have DoD Human Research Protection Official (HRPO) review to ensure compliance prior to start
- Conduct initial and continuing research ethics education for personnel who are engaged in the research
- Ensure IRB consideration of scientific merit of new research and any substantive amendments thereto
- Ensure additional protections for military research subjects to minimize undue influence
- Explain to subjects any provisions for medical care for research-related injury
- Report continuing review documentation, unanticipated problems involving risks to subjects or others, serious or continuing non-compliance, adverse events, research-related injury, and suspensions or terminations of research
- Appoint a research monitor, when necessary
- Safeguard for research conducted with international populations
- Protect pregnant women, prisoners, and children
- Comply with DoD limitations on research where consent by legally authorized representatives is proposed
- Comply with DoD limitation on exceptions from informed consent (e.g., 10 USC 980, 45 CFR 46, and 21 CFR 50)
- Comply with limitations on dual compensation for U. S. military personnel
- Follow DoD requirements for additional review for DoD-sponsored survey research or survey research within DoD
- Address and report allegations of non-compliance with human research protections
- Address and report allegations of research misconduct
- Follow procedures for addressing financial and other conflicts of interest
- Prohibit research with prisoners of war (POW)
- Comply with requirements for investigations of Food and Drug Administration regulated products (drugs, devices, and biologics)

- Follow recordkeeping requirements
- Support oversight by the supporting DoD Component (which may include DoD Component review of the research, requests for documentation such as Institutional Review Board (IRB) membership rosters, and site visits)

3. Please contact the supporting AF institution (e.g., via the Program Manager responsible for oversight of the relevant activity) with any questions for the AF HRPO.

Appendix D

Air University Approval to Conduct Research

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (AETC)

7 June 2016

MEMORANDUM FOR RECORD

FROM: HQ AU/A3A

SUBJECT: Approval to Conduct Research

1. As the Air University Authorized Institutional Official, I provide permission for research to be conducted at Air University.

   Principal Investigator: Tony L. Millican, Colonel, USAF
   AU Project Number: AU20160001
   Project Title: *Virtual Reality in Higher Education: A Case Study at the Air University Squadron Officer College*

2. The investigator present research protocol aims to explore the program participants' qualitative perspective on the subject of integrating Virtual Reality (VR) as a learning tool into the Squadron Officer School (SOS) curriculum and to produce a synthesis report on the findings. Three instruments will be used to collect data.

   a. Immersive Technology in Education Questionnaire (ITEQ)
   b. Semi-Structured Interview Baseline Protocol
   c. Focus Group Protocol

3. All surveys, questionnaires, interview protocols, and focus group protocols administered within Air University to students, faculty, staff, and others must have a survey control number (SCN). The investigator has been instructed to contact Air University Survey Control Officer to obtain the necessary information.

4. If you have any questions, I can be reached at anthony.cain@us.af.mil or by phone at 334-953-3056.

6/7/2016

X Anthony C. Cain

Anthony C. Cain, PhD
Associate Vice President for Academic Affairs
Signed by: CAIN.ANTHONY.CHRISTOPHER.1064185469

ANTHONY C. CAIN, PhD
Associate Vice President for Academic Affairs

Appendix E

Informed Consent

The Auburn University Institutional Review Board has approved this Document for use from 10/11/2016 to 07/21/2017
Protocol # 16-224 EP 1607

AUBURN UNIVERSITY
COLLEGE OF EDUCATION

EDUCATIONAL FOUNDATIONS, LEADERSHIP AND TECHNOLOGY

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMED CONSENT
for a Research Study entitled
"Virtual Reality in Higher Education: A Case Study at the Air University's Squadron Officer College"

You are invited to participate in a research study to evaluate the potential of integrating Virtual Reality (VR) technology as a learning tool within the Squadron Officer College (SOC) curriculum. The study is being conducted by Colonel Tony Millican, doctoral candidate at Auburn University under the direction of Dr. Frances Kochan, Professor Emerita, Auburn University Department of Educational Foundations, Leadership and Technology, and under the advisement of Dr. Fil Arenas, Associate Professor of Leadership and Communications Studies at SOC. You were selected as a possible participant because you have previously been involved in the internal SOC effort toward integrating VR into the curriculum and are age 19 or older.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to take part in a focus group or a personal interview that asks for you to share your ideas on the subject of integrating Virtual Reality as a learning tool in the SOC curriculum. Your total time commitment will be approximately twenty to ninety minutes. Focus group sessions will be video recorded and interviews will be audio recorded. The recordings will only be for the purpose of producing a written transcript of the session.

Are there any risks or discomforts? There are no foreseeable discomforts associated with participating in this study. As with any research project involving sharing personal ideas, a minimal risk of confidentiality or coercion exists. Careful efforts have been taken to ensure that your statements are kept in close confidence. From the beginning of transcribing your statements, you will be referred to using a fictitious identity. The association between your identity and the fictitious identity will be known only by the principal investigator who is bound by the Air University policy of Academic Non-attribution to never associate your identity to the comments that you provide. Moreover, his signature below provides his pledge as an Air Force officer that he will prevent in every way possible any form of coercion based on comments you provide in this research project.

Are there any benefits to yourself or others? If you participate in this study you can expect to be helping further research with regard to using VR as a tool for teaching and learning among future students and faculty at SOC. In addition, you will be helping to advance the primary

Participant's initial ___________

researcher's goal of completing a doctoral dissertation. We cannot promise that you will receive any direct personal benefit from participating.

Will you receive compensation for participating? There will be no compensation for participating in this study.

Are there any costs? If you decide to participate, there will be no cost to you.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If at any point you decide you no longer want to participate, you may dismiss yourself from the interview or focus group at any time. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with the Air University, Squadron Officer College, Auburn University, or the Department of Educational Foundations, Leadership, and Technology.

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Your name will not be used in connection with the study, but your non-identifiable role within the organization will be used along with a fictitious last name (e.g. "Instructor Seven" or "Staff Member Blue"). Information obtained through your participation may be used to fulfill an educational requirement, be published in a professional journal, and/or be discussed at professional meetings or presentations. The study is being supported by the Department of Defense (DoD) and the DoD may access records to ensure subject safety.

If you have questions about the study, *please ask them now* or contact Dr. Frances Kochan at kochafr@auburn.edu or contact:

Colonel Tony Millican at 334-301-4325; email tony.millican@gmail.com or
Dr. Fil Arenas at (334) 953-3551; email filomeno.arenas@us.af.mil

A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University office of Research Compliance or the Institutional Review Board by phone at (334) 844-5966 or email at IRBadmin@auburn.edu or IRBChair@auburn.edu

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

Participant's signature   Date

TONY L. MILLICAN, Colonel, USAF   Date
Investigator obtaining consent

Participant's Printed Name

The Auburn University Institutional Review Board has approved this Document for use from 10/11/2016 to 07/21/2017
Protocol # 16-224 EP 1607

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Appendix F

Immersive Technology in Education Questionnaire (ITEQ)

Immersive Technology in Education Questionnaire (ITEQ)

Air University Survey Control Number 16-120

IAW AFI 38-501, para 2.2, your participation in this survey is encouraged but voluntary. Strict confidentiality concerning any identifiers of individual survey respondents is maintained and data collection is anonymous. Your feedback is critical to academic program improvement and greatly appreciated.

Thank you for choosing to participate in this research project. The time it takes to complete the following questionnaire will be up to you, but your investment of at least a few minutes for each of the last 6 open-ended questions will be of great value to the mission of applying VR as a tool in graduate PME.

1. What is your position within or relationship to the Squadron Officer College?

2. If you previously graduated from SOS, when did you attend? (If not, please note "N/A").

3. What is your military rank, civilian grade, or contractor status? (Optional)

4. Other than within education, what is your primary 4-digit officer AFSC? If not a USAF officer, please choose the 4-digit career specialty that most closely relates to yours. A full list of officer AFSCs is available online at: http://tinyurl.com/Officer-AFSCs

Examples of 4-digit AFSCs:
11FX = Fighter Pilot // 21AX = Aircraft Maintenance
33SX = Communications & Information // 36PX = Personnel
44FX = Family Physician // 51JX = Judge Advocate

(If you prefer not to answer, just leave the following blank.)

My primary 4-digit officer AFSC (or equivalent) is: ________

5. What is the highest level of formal education you have completed?

The following six open-ended questions ask for your qualitative written input. Please read through all questions before starting in order to organize your thoughts. Write as much as you would like about either particular question.

6. What possible VR applications should SOC develop to support the curriculum? (Examples: multi-player Virtual Project-X game, "live-fly" air campaign planned & executed in VR, Cross-culture simulation experiences, etc.)

7. Beyond the SOC curriculum, (within your career fields or Air Force-wide), what opportunities would be ideal for VR applications to enhance mission effectiveness?

8. What potential challenges do you foresee in SOC's quest toward using VR as a tool in the learning environment? (Examples: Budget shortages, technology cycle or obsolescence, etc.)

9. What potential negative consequences do you anticipate that SOC could face as a result of introducing VR as a tool in the learning environment? (Examples: Less time available for other activities, disenfranchising students who don't like technology, etc.)

10. If you have ideas for potential solutions or remedies to overcome challenges or negative consequences mentioned in #8 or #9 above, please describe:

11. If you have any other comments, ideas, or suggestions on the subject of VR in Education that you would like to provide, please comment:

Thank you for your inputs!

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Appendix G

Semi-Structured Interview Baseline Protocol

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This document provides the prompts to be used as the baseline of the semi-structured interviews. Some of the questions will be formatted more distinctly based upon data analysis of the document review and analysis of the pre-existing qualitative open-ended questionnaire data.

Primary goal of the semi-structured interview is to allow the participant to share ideas on the use of VR in Education as the interviewer uses the following questions as probes/reminders.

Interviewer gives initial greeting as relevant followed by a brief personal introduction.

Interviewer reminds that the interview will be audio recorded for the purpose of producing a transcript. This reminder includes that throughout the process of making the transcript as well as analyzing the data, the interviewee's personal identity and comments will not be directly attributed to them by name.

During the session, we will discuss the following topics:

- Your experience in using VR and involvement in SOC's program to introduce using VR as a learning tool
- Perceived strengths, weaknesses, opportunities and challenges of using VR in the learning environment
- Ideas you may have for applications using VR that would be beneficial to the SOS curriculum going forward

Part 1 – Experiences with VR at SOC and personal experiences with VR

Prompt: What does "virtual reality" mean to you?

Prompt: Tell me about your experiences with virtual reality.

Prompt: How have you been involved in SOC's efforts in using VR?

Prompt: What was a memorable VR application that you've experienced?
Probe: How did that application make you feel?

Prompt: How easy or difficult was it to use VR?

Prompt: How likely do you think SOC students would be in using VR as a regular tool?

Prompt: What are your thoughts with regard to using VR as a tool for learning?

Part 2 – Related to Research Question Area 1 – Positives: Success factors, opportunities

Prompt: How can SOC best ensure success in using VR as a learning tool?

Prompt: What types of students or learning styles do you anticipate would be best helped by using VR?

Prompt: What types of learning outcomes do you think could be best impacted by using VR?

Prompt: From the questionnaire previously conducted, the ITEQ, some of the initial data analysis has demonstrated the following:

(Give hard-copy list of key trends demonstrated by the ITEQ data)

Does any of this information surprise you, and if so, in what way?

Prompt: (Engage further discussion on items listed.)

Prompt: Do you have any additional ideas on the positive side of VR that you thought of after taking the questionnaire? If so, please share.

Part 3 – Related to Research Question Area 2 – Negatives: Hindrances, Obstacles

Prompt: What challenges can you envision that SOC will have in the effort to integrate VR as a learning tool?

Prompt: Has VR ever given you any feelings of queasiness or uneasiness?

Prompt: What types of students or learning styles do you anticipate would be least likely to be aided by the use of VR as a learning tool?

Prompt: From the questionnaire previously conducted, the ITEQ, some of the initial data analysis has demonstrated the following:

(Give hard copy list of key trends demonstrated by the ITEQ data)

Does any of this information surprise you, and if so, in what way?

Prompt: Do you have any additional ideas on the negative side of VR that you thought of after taking the questionnaire? If so, please share.

Part 4 – Related to Research Question Area 3 – Applications

Prompt: On the questionnaire, the top SOC content areas for future VR applications are given on this list. (Present list of topics compiled from questionnaire data.)

Are there any areas on the list that you would like to add comments to?

Prompt: Do you agree/disagree with the items on the list and why?

Prompt: Why do you think participants expressed ____ as the top area?

Prompt: Are there topic areas that you are surprised not to see on the list?

Prompt: What existing VR applications have you experienced that are valuable ones, and why?

Prompt: If SOC had the resources to hire a VR programming team, what applications should the team be chartered to build?

Prompt: What ways could you envision redesigning parts of the SOC curriculum around newly-designed VR applications?

Prompt: Do you have any additional ideas regarding application of VR that you thought of after taking the questionnaire? If so, please share.

Thank you for your time. Is there anything you would like to add, or are there any questions that you have for me?