

Exploring the beliefs about education and the teaching practices of science teachers located at higher education schools inside the United States military

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Application for fulfilment of the requirements for the Degree of Doctor of Philosophy in Education

24 February 2025

ACKNOWLEDGMENTS

I would first like to acknowledge that the funding for this program of education was provided by the US Air Force as part of its US Air Force Institute of Technology Civilian Institution program. I would also like to make it explicitly clear that this work and views within are solely those of the author and do not necessarily represent the views of US Department of Defense or its components.

I would also like to acknowledge my advisors Dr. Ann Childs and Dr. Sibel Erduran in the Department of Education at the University of Oxford. My advisors provided incredible mentorship, extensive knowledge of science education, and near infinite patience that made the completion of this work possible.

Finally, I would like to thank God for sustaining me through life and blessing me with an amazing wife and family. It is to these that I dedicate this work.

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ABSTRACT

This study set out to close a gap in knowledge about the beliefs about education and the teaching practices held by science instructors in several US (United States) military, higher education settings. While the US military, official known as the Department of Defense, is primarily focused on generating combat capability, it also operates and staffs several undergraduate, higher education institutions known as the US military service academies. This study focuses on the unexamined undergraduate science instructors teaching chemistry, physics and biology within those higher education institutions.

Through interviews, document analysis and a survey, this study utilized a sequential, exploratory research method to discover and document the beliefs about education and teaching practices held by the science instructors in the US Army's, US Air Force's and US Navy's service academies. The study also sought to explore how these beliefs and practices might have been influenced by teaching in a military setting or instructor's military background.

Major findings of this study revealed that many science instructors held a belief that the aim of science education was to preparing cadets for future military service as an officer. The study also found that instructors often used the practice of incorporating military specific examples when teaching undergraduate science. Finally, it was additionally discovered that military science instructors were influenced by military culture and concepts such as hierarchy, standardization, and camaraderie could be connected to several instructor beliefs and teaching practices.

The findings of this study make significant contributions to closing a gap in knowledge about an atypical and almost undocumented cohort of science teachers in a higher education military setting. This unique viewpoint adds substantially diverse ideas to the literature and discussion on science teachers' beliefs about education and their teaching practices.

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1 INTRODUCTION

1.1 Introduction to the study

Imagine the following scene taking place inside a military installation located somewhere in the United States and guarded by security forces armed with assault rifles. Inside this facility is a military officer in a crisp uniform, military style haircut, and polished shoes preparing for their day's military duties. This officer typically serves as a combat pilot but for the last two years has been assigned to an instructor position. To begin their day the instructor walks down a hallway and enters a classroom full of approximately 25 officer candidates. These officer candidates are also dressed in crisp military uniforms and are eager to graduate and commission into active service within the military. As their instructor enters, one student calls the class to attention and the rest snap to attention standing behind their desks. The lesson is officially started when a designated student salutes the officer and reports in with "Sir, class is formed and ready for instruction." The officer returns the salute and instructs the class to take their seats. The officer unpacks some demonstration aids and begins with "Good morning class, as you are aware from last night's reading assignment, today's discussion is on *chemical equilibrium.*"

This scene is not a work of fiction. It comes from the personal account of one of the several hundred military officers who serve as academic instructors in the US military. Based on the military setting and military participants, an observer might have naturally predicted that the topic of the day's lesson would be something other than chemical equilibrium such as military tactics instruction or how to use a piece of military equipment. But this class is part of a general chemistry course at a post-secondary school located on a military installation. A hundred similar science classes are begun the same way every day cross the various United States military service academies. The students are 18-23 year-old officer candidates who are in the process of obtaining their Bachelor of Science degree prior to commissioning as officers in the Unites States Armed Forces. The instructor is a military officer and pilot but one who also holds a Master of Science degree in Chemistry and is completing a 3-year assignment as a general chemistry instructor.

This study focuses on these science teachers and explores their beliefs about teaching science at atypical post-secondary schools located within the US military. This chapter will provide an introduction to the study as well as an overview to the structure of the thesis. Section 1.1 presents a brief description of the US military setting, the rationale of the study, the aims of the study, and strategy of the study. Section 1.2 outlines of structure of remaining chapters.

1.1.1 Setting of the study: higher education within the US military

The setting of this study is the intersection of post-secondary education and the US military. The US military is a vast organization and typically more associated with its combat abilities than its efforts in higher education, see section 2.1. The majority of teaching and learning in the US military takes the form of military training and not academic education. Training is the process of preparing someone to perform a specific skill or task. Training is one of the principal activities of the 1.4 million active-duty military members when they are not deployed to an active combat zone, see section 2.1. Military training can range from simple to complex. Simple training can typically be completed in less than a day and might include something like learning how to don a gas-mask or fire a weapon. Complex military training can require years of sustained effort and include examples such as learning to pilot a fighter aircraft or skipper a submarine.

But education is different from training. Training is typically for a specific skill while education focuses on gaining general knowledge that can applied to a broad set of situations. And while training occurs at all US military facilities, there are very few facilities that have a primary mission that focuses on general education. If an educational researcher were to randomly select a location for a higher education study involving science teachers' pedagogical beliefs, the US military would be statistically unlikely location to be selected. In the US, higher education is highly decentralized with local governments and private organizations administrating almost all institutions. Of the nearly 4,000 degree-granting postsecondary schools in the US, only five undergraduate institutions are operated by the US Federal Government (Moody, 2021), see Figure 1. All five of these US Federal Government institutions are operated by a different branch of the US military.

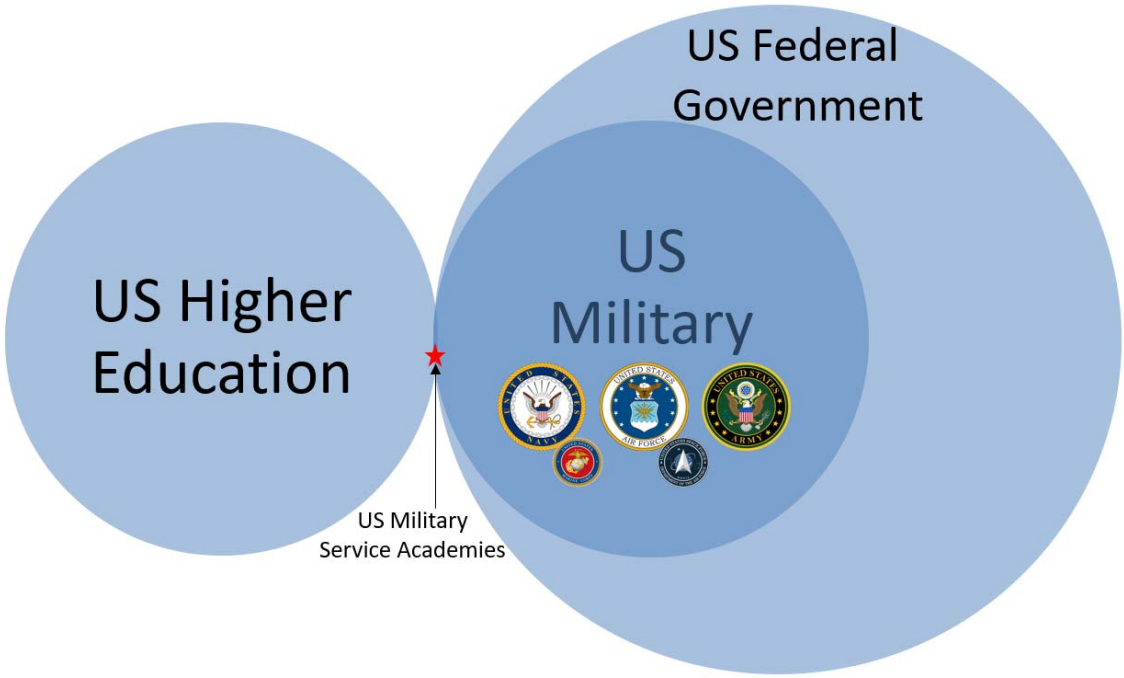


Figure 1: Within the United States there is very little overlap between Higher Education and the Federal Government or Military (5 of ~4,000 institutions). The US military service academies exist in that very narrow overlap and are non-traditional aspect of both US higher education and the US military.

These schools that lay at the intersection between the US military and higher education are known as the United States military service academies. Three are operated by US military branches of the Army, Navy, and Air Force and two are operated by military auxiliaries of the Coast Guard and Merchant Marines. A simple way of describing the service academies might be as post-secondary schools that provide both a liberal arts post-secondary degree and the full regimen of military training required to commission as a US military officer. Every student is a member of the active-duty military and will be required to serve as a commissioned officer after graduation. Like the students, all instructors at these service academies are employees of the Department of Defense and are either active-duty military officers or civil servants. This description has provided only a brief account of the setting of this study, with a full exploration of the US military's structure and culture in section 2.1. A brief summary of the rationale, and aims of the study will be presented next.

1.1.2 **Rationale for the study: addressing a relevant gap**

The rationale for this study is provided by two central aspects of science instructors and their beliefs at the US military service academies. First, there is almost no literature on these instructors,

which represents a gap in knowledge. Second, the gap is located in an atypical post-secondary school setting, addressing the gap could provide atypical insights relevant to traditional educational settings.

A gap in literature

The following aspects lead to a gap in knowledge, each aspect is fully documented in section 2.1.3. Service academies are undergraduate only institutions focused more on teaching than research. The quantity of academic research produced by faculty is small in comparison to large, research focused universities. Service academies offer no degrees in education and faculty conducting research typically focus on non-pedagogic elements of their field. Service academies are located within active military installations with various physical and administrative barriers to entry. Researchers from outside institutions seeking to study military members will encounter additional hurdles to access in addition to the traditional requirements of human participant studies. Researchers that do obtain access to study human participants in the US military tend to focus on topics such as leadership and organization (E. Murray, Berkowitz, & Lerner, 2019; Segal & Segal, 1983; Winslow, 2006) and not undergraduate education. The combination of these aspects leads to the strongest rationale for a study focusing on science instructors at the US military academies. Almost no literature exists on science instructors or their beliefs about teaching science at the service academies and this represents a gap in higher education literature.

Gap relevance to education literature

In addition to simply addressing a gap in knowledge, there are several reasons why addressing this particular gap is relevant to the larger body of education literature. These instructors are placed in an atypical setting for higher education. The military setting and culture are fully addressed in section 2.1 but in brief can be described as service oriented, highly structured, authoritarian, and warrior centric. Military members generally view themselves as warriors in service of their nation's defense. In these roles they maintain a state of combat readiness to deterring conflict. If deterrence fails, they are prepared to use deadly force. Aspects of military culture, such as a warrior mindset, represent a stark contrast to culture in non-miliary setting and especially those found at traditional US higher education institutions. Perhaps by addressing the gap in knowledge on science instructors in a military

setting, novel conceptions of science teaching can be described. Perhaps these conceptions could not be otherwise gained from more traditional higher education settings and will provide new understanding and insight into relevant questions in science education. Not only is there a gap, but the gap is relevant.

1.1.3 Research aims of the study

The aims of this study are to narrow the gap in knowledge by exploring the beliefs about teaching and teaching practices held by science teachers in US military settings. In addition to identifying the teaching beliefs and practices, the influences on those beliefs and practices will be investigated. Lastly, as the US military is not a homogenous setting and distinct military cultures exist between the branches of the US Army, Air Force, and Navy, the study will seek to explore if and how teachers' beliefs and practices vary across the different military services. These three aims have been summarized in the following research questions, more completely detailed in section 2.3.

- What are the reported pedagogical beliefs about teaching science and pedagogical practices of science instructors at the US service academies?
- What are the reported influences on these beliefs and practices?
- Do these beliefs and practices vary between groups in the military and if so, how?

1.2 Structure of the remaining chapters

This section describes the structure of this thesis by presenting the contents of the remaining chapters. Chapter 2 presents a literature review and provides further details on the purpose, structure, and culture of the US military as the setting of this study in section 2.1. The conceptual framework of teachers' pedagogical beliefs and practices is presented in section 2.2. Section 2.3 concludes with a presentation of the operationalized research questions.

Chapter 3 provides further details on the overall methodological approach to the study. Section 3.1 describes how an exploratory mixed methods sequential design was selected as well as reflectivity of the researcher as a member of both the academic science educational community and the US military. Aspects with how the qualitative data was accessed, generated, and analyzed are presented in section 3.2. A discussion on how the quantitative data was developed and analyzed is

presented in section 3.3. The chapter concludes with section 3.4 that discusses atypical questions regarding ethics in a military setting as well as discussing limitations of the methodology.

Chapter 4 is the first of three chapters that presents evidence and discusses the findings of the research questions. Section 4.1 presents an overall answer to the first research question by suggesting that most instructors' beliefs about teaching and teaching practices are nested within the idea of preparing officers for military service. Section 4.2 presents a number of teachers' beliefs and practices in the classroom.

Chapter 5 presents the findings and discussion for the second research question on the influences on teachers' pedagogical beliefs and their practices. A unifying theme of science teaching as a military operation is presented and section 5.1 presents how teachers are hired and trained in some very similar ways to how the military hires and trains soldiers. Section 5.2 presents how the military practices of hierarchy, standardization, and camaraderie are found within in science departments and how these influence teacher's pedagogical beliefs and practices.

Chapter 6 presents data and discusses answers to the final research question on how pedagogical beliefs and practices might vary across different military settings. Section 6.1 presents a general discussion on how different groups were identified and examined. Section 6.2 presents data on variations between civil servant science instructor and active-duty military science instructors. Section 6.3 presents data on variations across departments and across the three service academies.

Chapter 7 concludes the thesis with a summary of key findings and how the research questions have been addressed in section 7.1. Section 7.2 reemphasizes the significance of the study and how it has addressed a particular gap in the literature. Section 7.4 suggests how ideas developed in this can offer new ideas to science education researchers as well as offers ideas for future studies.

2 LITERATURE REVIEW

Introduction to the chapter

This chapter describes the conceptual framework for this research study. Section 2.1 begins with the purpose, structure, culture of the US military as the setting for this study. This section also examines the literature on science teaching at the US military service academies. Section 2.1.3 presents the conceptual frameworks of teachers' pedagogical beliefs and practices and their influences. The chapter concludes with a presentation of the operationalized research questions in section 2.3.

2.1 Understanding the US military

Describing US military will be useful in answering the research questions and a discussion of the relevant topics will be presented. Section 2.1.1 begins with a general description of the US military's purpose and the structure of its various branches and hierarchy. Section 2.1.2 proceeds with a presentation of the literature on military society and culture. Section 2.1.3 focuses to a discussion of the literature on the US military service academies, the specific location of this study within the larger US military setting.

2.1.1 US military: purpose and structure

This section describes the general purpose and structure of the US military. Within military language, purpose and *mission* are synonymous terms (A. van Dijk & Soeters, 2008). As officially stated, the "[US military's] mission is to provide the military forces needed to deter war and ensure our nation's security" (U.S. Department of Defense, 2022), and like most militaries, the US's falls within the government and its purpose is to fight and win its nation's wars. Officially named the Department of Defense, the US military is one of several departments in the Executive branch of the government and the US President serves as Commander and Chief. Mission, or as the author often hears "*the* mission", is a rich and almost sacred term that summarizes purpose and actively shapes almost every element within the military. Completing the mission is the ultimate goal and a litmus test for all military form and function (Priest, 2004). Elements failing to meet the mission are unsympathetically eliminated and elements that meet or exceed it are celebrated and reproduced.

Like many governmental organizations, the US military is a service. Similar to mission, *service* is also a rich and pervasive term in military language and is used in organization titles (service branches), core values ("service before self") and for individuals (service members) to name just a few (A. van Dijk & Soeters, 2008). Ultimately, the US military is in service to the nation and while it might have some self-determination in how it accomplishes the mission, it is not at liberty to change it (E. A. Cohen, 2019).

Not many individuals truly understand the vast scope and cost of defending US national security. While the phrase "freedom isn't free" is traditionally used to describe the sacrifice of individual soldiers, it could easily be applied to the economic cost of the US military. The 2022 annual budget for the US military exceeded $753 billion USD (U.S. Department of Defense, 2022). When viewed globally, the US military budget accounts for roughly one third of the global spending on military defense and more combined than the acknowledged amounts of the next eight highest countries (Tian et al., 2017). An important note is that these are acknowledged values and certain countries choose not to disclose their true budgets for purposes of security or secrecy. While academics generally seek to produce knowledge in an open setting, there are many top-secret programs that various militaries seek to keep that way.

In terms of personnel strength, with over 2.9 million members, the US miliary is the largest military and the largest employer in the world (Ainspan, Orvis, & Kelley, 2019; U.S. Department of Defense, 2022). Of the almost 3 million employees in the Department of Defense, 1.3 million are uniformed military service members and the other approximately 1.6 million are civil servants (Office of the Secretary of Defense, 2018). The primary distinction between these two types of employees is that military service members can be directed into combat situations while civil servants will typically not be exposed to combat operations. Considering the cost and size, it is unsurprising that the US military is generally considered as the most powerful military in the world (Constantinescu, 2020). The US military is stationed in over 160 counties around the world and the sun never sets on US military installations (U.S. Department of Defense, 2022). The next section will examine how the US military is composed of service branches with specialties.

Military service branches

Because warfare can occur on land, at sea, in the air, and in space, several US military services branches have been formed to specialize in conflict in each. Russia's 2022 invasion of Ukraine showcased how even cyberspace and information warfare should be considered combat zones along with the prementioned traditional battlefields (Serpanos & Komninos, 2022). The five branches of armed forces within the US Department of Defense including the Army, Navy, Air Force, Marine Corps, and Space Force. Table 1 has been developed to provide a summary of the mission, roles, strength, motto (beliefs) of each service branch (Air Force Personnel Command, 2022; Commandant of the Marine Corps, 2016; Defense Manpower Data Center, 2022; Garamone, 2019; House Appropriations Committee, 2021; Office of the Under Secretary of Defense & (COMPTROLLER), 2019; US Space Force, 2021). With an average of 200,000 military personnel in each service branch, the descriptions provided should be considered broad brush and general in nature.

Table 1: Service Branches of the US military with respective features. Data sourced from (Air Force Personnel Command, 2022; Commandant of the Marine Corps, 2016; Defense Manpower Data Center, 2022; Garamone, 2019; House Appropriations Committee, 2021; Office of the Under Secretary of Defense & (COMPTROLLER), 2019; US Space Force, 2021)

Service Branch	**Air Force**	**Army**	**Marine Corp**	**Navy**	**Space Force**
Primary Battlespace	Air	Land	Sea/Land	Sea	Space
Missions & Roles	-Air supremacy -Global strike -Rapid global mobility -Global intelligence and reconnaissance	-Prompt and sustained land combat -Combined arms operations	-Amphibious warfare -Expeditionary warfare	-Sea control -Power projection -Deterrence -Maritime security -Sealift	-Space Security -Information Mobility -Space Domain Awareness
Enlisted	261,000	368,000	153,000	284,000	2,900
Officers	60,900	93,600	21,500	56,500	3,500
Civil Servants	152,000	252,000	35,000	278,000	8,000
Motto	"Aim High ... Fly-Fight-Win"	"This We'll Defend"	Semper fidelis "Always faithful"	Semper Fortis "Always Courageous"	Semper Supra "Always above"
Associated Military Service Academy	US Air Force Academy	US military Academy	US Naval Academy1	US Naval Academy	US Air Force Academy1

[1] The US Marine Corps and US Space Force do not have their own military service academies and obtain their commissioned officers from the US Navy and US Air Force Academies respectively.

While Table 1 provides a brief summary, a description of each service will be provided below that utilizes both literature and author commentary based on 23 years' experience in the US military. These descriptions are useful as each undergraduate education military service academy is operated by a different military service.

The US Army

In the non-military world, the term Army is often applied to all military members in military service but in the current US military it only applies to one military branch of service. As a ground-based force, the US Army might be the most traditionally recognizable type of military force as armies have existed for millennia (Briant, 2012). The US Army excels at operating on land in large formations and for extended periods of time. Army soldiers fight with a variety of weapons from small arms (personal weapons such rifles, hand grenades, and knifes) up to heavy weapon systems (including battle tanks, artillery, and rocket delivery systems). The comparably short to intermediate range of these weapons dictate that Army soldiers will generally experience combat at close ranges to include visual line of sight and even down to hand-to-hand combat (D. Grossman, 2014). While not just large, the Army's mission is to provide long term logistics to support both combat and occupational operations for years in a combat zone. Mobilizing this logistical train is a massive undertaking and generally results in the Army being the slowest to deploy to the battlefield and ill equipped for responding to urgent threats. But when the US wants to establish an enduring military presence somewhere in the world, the US Army is the service that will provide the "boots on the ground" presence (McGrath, 2006; Weiss, 2011).

The US Navy

The US Navy has the mission of conducting military actions at sea, including over and under (Baer, 1996). US Navy vehicles include craft such as destroyers, frigates, aircraft carriers, aircraft, as well as attack and strategic submarines. Naval vessels are typically capable of operating for months at sea between resupply. US Navy weapons are typically more technical in nature and include naval artillery, long range missile, torpedoes, and strike aircraft based from aircraft carriers. The increased range of these weapons means that sailors will typically experience combat at longer ranges that

exceed line of sight (D. Grossman, 2014). The Navy is more naturally suited for mobility and can deploy more swiftly than the US Army. When they do deploy, naval ships do not deploy individually but as a part of a flotilla called a Carrier Strike Group. The combined military power of the warships, submarines, and strike aircraft in a single US Navy Carrier Strike Group exceeds that of all but a handful of nations in the world (Morua, 2000). The US Navy maintains 9 Carrier Strike Groups.

The US Marine Corps

The US Marine Corps can be described as a small, mobile version of the US Army that is based on and deploys from US Navy ships. Their role is to excel at high intensity assaults such as securing a beachhead or dynamic advances on land. Marines can be considered a type of elite or special forces unit and their combat engagements will be high intensity and at the closest ranges (D. Grossman, 2014). Marines are described as being in the business of kicking down doors and shooting people (Todd, 2014, p. 20). They fight with similar weapons as the US Army but might trade heavy tanks for amphibious landing craft. For their increased combat intensity marines trade a logistical support and US Marines can only maintain an assault for a couple of weeks before running out of supplies (Bickel, 2018). In addition to combat expertise, US Marine Corps are also very adaptable to other missions and regularly conduct Military Operations Other Than War (MOOTW) and perform missions of humanitarian assistance or disaster response (Bonn & Baker, 2000).

The US Air Force

The US Air Force's mission is to operate in the air and space domains. The Air Force can deliver strikes globally with bombers or long-range missiles. They are equipped to establish air superiority with fighter aircraft and they can provide transportation services with large cargo aircraft. The weapons of the US Air Force are some of the costliest and most technically advanced and include stealth fighter aircraft, transportation aircraft, refueling aircraft, and intercontinental ballistic missiles. Most Air Force bases are located away from the frontline and Air Force members are often above or far away from combat (D. Grossman, 2014). Through the use of aerial refueling and rotating crews the US Air Force can generate long duration bomber sorties lasting up to 44 hours that launch from

US soil, traverse the globe to deliver munitions to a combat zone in the Middle East, and return to the US all without landing (French, Bisson, Neville, Mitcha, & Storm, 1994).

The US Space Force

The newest service branch, the US Space Force, was recently created in 2020. The US military has operated in space since the 1960s and this branch was created by extracting all the space related capabilities and personnel from the other branches (Arnold, 2022). The Space Force members operate remote space satellites to provide communication, navigation, and observational data. Space is the most technologically demanding of all the battlespaces and Space Force equipment is the costliest of all the services. Currently there are no manned space systems in the US Space Force and any engagement with enemy forces would be conducted remotely or autonomously through the use of satellites (Wertz & Bell, 2003).

In summary, each US military branch's mission is to provide combat capability in different domains with different weapons. But US military operations rarely involves only one service and are more often joint operations between the services (Chairman of the Joint Chiefs of Staff, 2017). A modern joint operation might involve an assault conducted by Army or Marine Corps soldiers supported by Navy artillery fire, Air Force close air support, and Space Force communications and intelligence. The next section turns to examine the structure of the military members that make up the different services.

Military personnel rank structure

All of the students and approximately half of the science instructors at the service academies are military members. When addressing research questions on the beliefs about teaching of military science instructors it is useful to provide a reference point to where they sit within the military. The 1.3 million US military service members are organized in hierarchal ranks. Military ranks, such as captain or sergeant, generally corresponds to levels of responsibility, experience, training or education. Table 2 presents the most common ranks, a brief description of roles, responsibility levels and typical levels of education. The two major groups of military personnel include commissioned

officers and the enlisted members. A small warrant officer corps exists in some service branches. The higher ranks are placed at the top of Table 2 and officers outrank enlisted personnel.

Table 2: US military Ranks and Structure (Bass, 2022; Cancian, 2020; Kapp, 2021; U.S. Department of Defense, n.d.)

	Grade	Army Rank	Air/Space Force Rank	Marine Corps Rank	Navy Rank	Grouping	Education
Commissioned Officers hold presidential commissions, ranks confirmed by the Senate	O-10	General			Admiral	General Officers Strategic level leaders 25+ years of service	Post graduate degree: Majority
	O-9	Lieutenant General			Vice Admiral		
	O-8	Major General			Rear Admiral (Upper Half)		
	O-7	Brigadier General			Rear Admiral (Lower Half)		
	O-6	Colonel			Captain	Field Grade Officers organizational level leaders 12-25 years of service	
	O-5	Lieutenant Colonel			Commander		
	O-4	Major			Lieutenant Commander		
	O-3	Captain			Lieutenant	Company Grade Officers Unit leaders 0-12 years of service	Bachelor's degree: Required
	O-2	1st Lieutenant			Lieutenant, Junior Grade		
	O-1	2nd Lieutenant			Ensign		
Warrant Officer an officer/enlisted bridge	W-1 - W-5	Warrant Officer or Chief Warrant officer				Warrant Officer Technical experts, most with enlisted service 15+ years of service	Post-secondary education: Most
Enlisted Personnel bulk of US military, specialists and tactical leaders	E-9	Sergeant Major	Chief Master Sergeant	Master Gunnery Sergeant	Master Chief Petty Officer	Senior Noncommissioned Officers Leads teams and preserves heritage 15+ years of service	Post-secondary education: Most
	E-8	Master Sergeant	Senior Master Sergeant	Master Sergeant	Senior Chief Petty Officer		
	E-7	Sergeant First Class	Master Sergeant	Gunnery Sergeant	Chief Petty Officer		
	E-6	Staff Sergeant	Technical Sergeant	Staff Sergeant	Petty Officer First Class	Noncommissioned Officers Backbone of US military: increased leadership and task execution 3-20 years of service	Post-secondary education: Some
	E-5	Sergeant	Staff Sergeant	Sergeant	Petty Officer Second Class		
	E-4	Corporal/Specialist	Senior Airman	Corporal	Petty Officer Third Class		
	E-3	Private First Class	Airman First Class	Lance Corporal	Seaman	Junior Enlisted typically in some kind of training status or on their initial assignment. 0-2 years of service	Secondary education: Most
	E-2	Private	Airman	Private First Class	Seaman Apprentice		
	E-1	Private (Recruit)	Airman Basic	Private	Seaman Recruit		

Most military members serve their entire careers as either an enlisted member or as an officer, and it would be incorrect to assume that most new officers have worked their way through the enlisted ranks first. For officers, the Army, Air Force, Marine Corps and Space Force utilize common rank terminology while the US Navy uses alternate names for the same corresponding ranks. For enlisted ranks, there is far greater individualized terminology across the services. Another aspect to understand about military force structure is the number of military personnel for each rank or grade Table 3 displays force strength by grade.

Table 3: Sept 2022 US military Force Strength by Rank (Defense Manpower Data Center, 2022)

	Grade	Rank	Count	% of military
	All	**Total Military Personnel**	**1,317,067**	**100%**
Commissioned Officers	O-10	General/Admiral	41	0.003%
	O-9	Lt Gen/Vice Adm	152	0.01%
	O-8	Maj Gen/Rear Adm (Upper)	286	0.02%
	O-7	Brig Gen/Rear Adm (Lower)	384	0.03%
	O-6	Colonel/Captain	11,110	0.84%
	O-5	Lt Colonel/Commander	27,529	2.09%
	O-4	Major/Lt Commander	45,664	3.47%
	O-3	Captain/Lieutenant	73,780	5.60%
	O-2	1st Lt/Lt, Junior Grade	31,399	2.38%
	O-1	2nd Lt/Ensign	27,028	2.05%
		Total Officers	**217,373**	**16.5%**
Warrant Officers	W-(1-5)		19,269	1.46%
Enlisted Personnel	E-9	various terms	10,477	0.80%
	E-8	various terms	26,677	2.03%
	E-7	various terms	93,868	7.13%
	E-6	various terms	167,132	12.7%
	E-5	various terms	223,038	16.9%
	E-4	various terms	261,814	19.9%
	E-3	various terms	186,958	14.2%
	E-2	various terms	54,891	4.17%
	E-1	various terms	42,812	3.25%
		Total Enlisted	**1,067,667**	**81.06%**
Other	Cadet		12,758	0.97%
	All	**Total Military Personnel**	**1,317,067**	**100.00%**

The enlisted grades compose 81% of the military while commissioned officers compose approximately 16% of the military force. As pointed out in Table 2, one distinction between US military officers and enlisted is the requirement for officers to hold post-secondary school degrees. Although the enlisted force make up 81% of the US military, the teaching of science at US military service academies only involves officers (Bass, 2022). As such, enlisted members are not the focus of this study and will receive minimal attention. The participants in this study come from the grades of O-3 through O-6 and represent the top ~12% of the military.

In summary, section 2.1.1 has described the purpose and structure of the US military. Purpose was augmented with ideas of mission and service. Structure was explored through a short description of the service branches and military ranks. These descriptions will provide utility through relevant context when answering research questions. The following section will turn to an examination military society and culture as additional support in answering the research questions.

2.1.2 US military: society and culture

The previous section investigated US military purpose and structural elements, this section seeks to explore military society and military culture. The section begins with a preface on violence as a possible influence on military culture and society. It proceeds with an examination of military society as an occupation or an institution. The section then moves to a description of common cultural elements of the US military. For this study, society is being defined as the structural elements of a group of individuals living togethering sharing social interaction and culture as "the set of attitudes, values, beliefs, and behaviors shared by a group of people" (Matsumoto & Juang, 2016, p. 16). Like structure, these topics are discussed as they are vital in addressing research questions related to understanding teaching practices and beliefs as well as the contextual or cultural influence on them.

Does violence make the military different?

The military and violence are inseparably linked. Anecdotally, the author has heard their career nobly described as "supporting and defending the US Constitution" as well as being informed they were in the grisly "business of breaking things and killing people." In reality, a majority of US military members serve in support roles and will never directly participate in battlefield violence

against another human (D. Grossman, 2014). But the author notes that regardless of being in a support role or at the "the tip of the spear", almost all military members still feel the responsibility of having their hand somewhere on the spear shaft, even if it is placed further away from the killing end. Regardless of how conflict is articulated, the US military accomplishes its mission through its ability to produce intense, state-controlled, organized violence (Bredow, 2018). Security is vital to state survival and Max Weber defined this monopoly on violence as the key attribute of a state in his 1919 essay *Politics as a Vocation* (Waters & Waters, 2015). Because it has less utility in answering the research questions, an in-depth discussion of violence in the military will not be presented here. But others have grappled with the topic (Burke, 2007; Kurtz & Turpin, 2008).

To frame a discussion on military society and culture, two important questions should be addressed. First, if all societies have differences, is military society somehow more uniquely different and worthy of understanding? Second, assuming the military is somehow different, is violence the primary driver of those differences?

When addressing the first question of uniqueness, it seems that with the vast array of cultures and professions it is a bold claim to say that one society or culture is *more* significantly unique than others. But several military social scientists argue that a military society is unique and should be a considered a special society (Boene, 1981; VanLandingham, 2015). Language such as "the military world and the military mind-set have constituted a quite different, quite separate environment from the other institutions, groups and aggregates of civil society" (Caforio, 2018a, p. 4) can be readily be found in literature on military society and culture. Claims of this sort answering the first question above usually tie in the second question in their reasoning. Grossman (2014) argues that violence against a human is considered taboo in most societies, and military societies are set apart to separate that taboo from the rest of society. Segal and Kramer use the violence argument to add an aspect of individual commitment and the employer/employee relationship in a military society (Segal & Kramer, 1977).

> *"Because of its unique social function – the legitimate management of violence – the military requires of its personnel a degree of commitment that differs from that required by other modern organizations. Military personnel, unlike their civilian counterparts, enter into a contract of unlimited liability with their employer." (Segal & Kramer, 1977, p. 28)*

Their argument centers around a liability argument that few organizations can knowingly and justifiably require their employees to give their life for work. Whether military society is uniquely different enough to be considered a special society and whether those difference can be tied to its connection to violence seems difficult to irrefutably establish. But it does inform on elements of military society and culture and those will illuminate answers to the research questions.

The development of military focused sociology

While militaries and warfare have existed for millennia, literature on military society was effectively non-existent prior to the last century and the majority of literature consisted of military histories or accounts of military tactics. Accounts of military histories are numerous, one famous example is Homer's *Iliad*, an 8th century BC account of the Trojan War. Accounts of military engagements serve as case studies at many military training and education programs (Howard, 1962; Jessup, 1979; Segal & Ender, 2008). Although existing in much reduced quantity, literature focusing on military strategy or doctrine have also existed for millennia. The most famous example is likely Sun Tzu's *The Art of War* composed the 5th century BC. Similar to military histories, some military strategy and doctrine has proven so enduring as to be included in many officer education programs (Caforio, 2018b; Segal & Ender, 2008). Military strategy is often studied throughout a military career. One notable instance of this includes US General Norman Schwarzkopf, the leader of the coalition forces in the 1991 Gulf War, who reported heavy use and inspiration from the 2,500 year old *The Art of War* while developing his very successful 1991 invasion campaign of Iraq (Hlavatý & Ližbetin, 2021). But while the histories, and tactics are important and the most abundance sources of military literature, they have less utility in informing on the setting of this study. Recent works in military sociology are useful for this study though.

Prior to World War II, not many works on military sociology were produced (Caforio & Hong, 2018). Some outliers to this in include Herbert Spencer's ideas about military societies evolving into industrial ones (Spencer, 1882), Emile Durkheim's consideration of military service on suicide rates (Durkheim, 2005) , and Max Weber developing his ideal-type bureaucratic organization from a model of the Prussian Army (Weber, 1978). During the Second World War, the United States

mobilized most aspects of the country for war including a number of sociologists. This resulted in a flood of American literature which began to dominate the field of military sociology (Segal & Ender, 2008). During the war much of the literature was aimed at assisting the war effort, but after the conflict, the focus began to shift to peace time study. In the 1960s the number of military coup d'états increased around the world in places such as Africa (Decalo, 1973). In response to these unsettling events, social scientists began to concentrate on understanding the nature of the *civil-military relations*. Civil-military relationship focuses on how a society's military forces interact with the rest of that society. One of the central ideas in civil-military relations is explaining how a civilian society maintains control over its military when the military holds all the guns. Understanding this idea was deemed necessary in order to prevent future military coups from occurring. Civil-military relations are useful to this study in that they articulate many of the possible differences between a military society and a civilian society.

Two leading voices emerged in the subfield of civil-military relations, that of Samuel P. Huntington with his *The Soldier and the State* and Morris Janowitz with *The Professional Soldier* (Huntington, 1957; Janowitz, 1960). Each sociologist took a different approach the problem of how a civil society could control their military. Huntington put forward an argument that military culture was both different and irreconcilable with civilian culture and that in order for civilians to maintain control of the armed forces, the military members, in particular the officer corps, needed to be *professionalized* (Huntington, 1957). Janowitz took a different approach from Huntington. While he agreed with the claim that military culture was different from civilian culture, he argued that civilian control of the military could be best sought by enacting policies to transform military culture into one indistinguishable from civilian culture (Janowitz, 1960). Janowitz's suggested policies included changing how the military exercised authority and how it recruited its soldiers to mention two. Huntington and Janowitz's views on military-civil relations remained somewhat irreconcilable until Charles Moskos produce a pluralistic theory incorporating both writers viewpoints in the Institutional/Occupation model (Moskos, 1973).

US military society: An institution or an occupation?

Moskos unified Huntington's and Janowitz's theories with his Institutional/Occupation (I/O) interpretive model of military society (Moskos, 1977, 1986). Moskos used the term *institution* to describe a Huntington type military society as very different from a civilian society where forces such as values and norms that transcend individual self-interest would direct behavior (Moskos, 1977). Moskos used the term *occupation* to describe an ideal Janowitz style military society where behavior was driven more by marketplace forces and where an individual's self-interest has higher priority than their organization's interests. The institutional/occupational model provides an excellent framework for discussing the various elements of military society and how they might differ from a civilian one. Moskos' model is also useful because it provides a spectrum of descriptions rather than a single one. Several branches of military service were described in section 2.1.1, and different military units will have different alignments within the institution or occupational model spectrum.

Moskos institution/occupation model evaluates military society with a number of variables such as values, norms, compensation, and practices. The model can be applied to both large and small units within the military. To present the elements of the model, Table 4 was developed from the original tables (Moskos, 1981, p. 2, 1986, p. 378).

Table 4: Moskos' Institutional versus Occupational model of the military (developed and adapted from (Moskos, 1981, p. 2, 1986, p. 378))

Military Social Organization: Institutional versus Occupational		
Variable	**Institution**	**Occupation**
Legitimacy	normative values (service; duty, honor, country)	marketplace economy
Societal Regard	esteem based on notion of service or sacrifice	prestige based on level of compensation
Role Commitments	diffuse; primary commitment to organization	specific; segmental commitment to organization
Reference Groups	"vertical" - within organization	"horizontal" -- external to organization
Evaluation of Performance	holistic and qualitative	segmented and quantitative
Legal System	military justice and broad purview over military member	civilian jurisprudence, narrow purview over military member
Basis of Compensation	rank, seniority, and need	skill level and manpower
Mode of Compensation	much in non-cash form or deferred	salary and bonuses
Level of Compensation	decompressed, low recruit pay	compressed; high recruit pay
Post service status	veteran's benefits and preference	same as civilian
Residence	adjacency of work and residence locales	separation of work and residence locales
Spouse	integral part of military community	removed from military community

The first variable in Moskos' model is legitimacy. In Moskos' institutional model, legitimacy is framed in terms of values and norms. Moskos describes this as a solider who might have a "purpose transcending individual self-interest in favor of a presumed higher good. Members of an institution are often seen as following a calling" (Moskos, 1981, p. 3). Values such as service, duty, selflessness are at the core of what legitimizes the military profession (Franke, 2000). In the juxtaposed occupational military model, rather than by values, legitimacy is established by value to the marketplace economy. In this view, a military member might provide national security in exchange for marketplace compensation, a bit like a mercenary. This first variable illustrates Moskos' spectrum of descriptions, individual units might contain elements of both. Legitimacy ties into the second variable of societal regard. In the institution model, society esteems the military and its members for their service and sacrifice. In the occupational model, esteem from society is rather based on the level of compensation of military members. Data confirm that the US public holds the US military in not just high esteem, but almost the highest amongst institutions (Brenan, 2021; J. Jones & Saad, 2016).

When compared to other organizations such as the presidency, lawmakers, and the courts, the US military has secured the highest position of regard by the US public for decades. Even when called upon to serve in the generally unpopular wars of Iraq and Afghanistan, US societal regard for the US military actually increased (Burbach, 2017). In the US there seems little evidence to suggest that this high esteem is a result of the pay levels provided to military members.

Moskos' next variable is the nature of role commitments. In the institutional model, military members will have commitments that are diffusely spread across the entire organization, such as to their service branch. Institutional military members will be expected to perform duties outside of their specialty (Moskos, 1986, p. 380). Occupational model members would have commitments that focus on only certain elements of their organization. The author has experienced more institutional role commitments and a breadth of assignments to support the Air Force in general. While their job series is labelled as Developmental Engineer, they have performed a variety of additional duties including: security investigation officer, aircraft crash site commander, unit deployment manager, court marital juror, unit physical fitness leader, booster club organizer, just to name a few. Roles commitments also ties in to Moskos' uses of references groups, or who members identify with, as a variable (Moskos, 1986, p. 380). Moskos' occupational model suggests that individuals share a sense of identity horizontally with those who perform similar work and this identification could exceed their organization bounds. In the occupational model, military officers who were electrical engineers would identify more with other electrical engineers both across and external to the military. In institutional model, identity is created and shared vertically in an organization. The corresponding example would be the electrical engineer identifying more with another member in uniform, regardless of job, over an electrical engineer outside of the military.

The evaluation of performance is also a variable in the I/O model. The occupational model bases performance evaluation on segmented elements of a profession and is quantitative in nature. Engineers would be evaluated on their performance as an engineer. In the alternate institutional model, performance evaluation is holistic and qualitative. For officers in the US military, performance evaluation follows the institutional approach. In addition to primary duties, evaluations include assessments of physical fitness, character, leadership & teamwork, dress and appearance and other

holistic topics (Department of the Navy, 2021; Headquarters Department of the Army, 2019; Office of the Under Secretary of Defense for Personnel and Readiness, 2022). The holistic approach is not subtle, the newly formed Space Force recently eliminating their traditional physical fitness test in pursuit of a more "holistic health and fitness approach" (R. S. Cohen, 2022). Instead of administering the once-a-year battery of physical tests, this technologically savvy service is exploring fitness assessment through the use of fitness trackers that continuously monitor physical activity throughout the year.

Moskos' next variable examines legal jurisdiction. In the occupational model there is no additional legal jurisdiction of members beyond civil laws. In the institutional model, an additional military law exists with broad preview over the military member's life. All US military members are subject to the Uniform Code of Military Justice (UCMJ) such as in the intuitional model (U.S. Congress, 1958). This code applies to military members both in their duties as well as when off duty or off base (Moskos, 1986, p. 380). Under the UCMJ, military members are held to additional laws not levied upon the general public, some laws involve special limitations to free speech or conduct prejudicial to good order and discipline (*United States v. Howe*, 1967). Violating military law has serious consequences. The author has served as a juror in a military courts martial trial, in that trial a military member was charged, convicted, and sentenced to jail for committing a sexual assault off base during their free time. While this crime could have also been tried in a civil court, it was tried under the UCMJ and in additional to a jail sentence, the member lost pay, rank, and received a dishonorable discharge from the military.

Compensation is another set of variables in the institutional/occupational model and address *basis*, *mode* and *level* of compensation. In the institutional model, pay is determined by rank and time in service, there are no mechanisms to ask for a raise and as Moskos states "notions of 'overtime pay' are alien to the institutional military" (Moskos, 1986, p. 379). Although compensation is generally low, it may be supplemented in non-cash forms as in benefits and it may be provided after the term of military service is over. Compensation basis in the occupational model is based on skill and manpower needs, is generally higher, and is typically provided only during service. Current US military practices follow a more institutional model. US military pay is determined by tabular data as

opposed to member performance (Defense Finance and Accounting Service, 2022). All US military members with the same rank and years of service length receive the same basic pay regardless of occupation or service branch. This basic pay is augmented based on need of the individual circumstances. A supplemental housing allowance is determined by assigned duty location and a military member with dependents will receive a small increase to their housing allowance. Similar to compensation, post service status is a variable in the I/O model. In the occupational model, status is equivalent to any civilian status. In the institutional model, veterans receive benefits and preference. In the US military veterans have access to benefits provided by the Department of Veterans Affairs such as health care services, disability compensation, access to favorable home loans, and educational benefits (U.S. Department of Veterans Affairs, 2022).

Moskos' last variables include residency and spouse involvement. In an institutional model military members' residence is collocated with their place of work, in an occupational model they are separated. This is a variable with wide discrepancy in the US military and examples on both spectrums exist. Certain positions, ranks and assignments will mandate that US military members live collocated to their place of work. But if mission requirements do not require it, many US military member are allowed the freedom to pursue off base housing locations. Living in close proximity facilitates the variable of spouse involvement. In the institutional model, spouses and family members of military members are an integral part of the military community, often leading volunteer organizations located on base (Moskos, 1981). In the occupational model, spouse involvement would be equivalent to what would occur in a civilian setting. Like residency, different US military units have different levels of spouse involvement. The author has been a member of units with no spouse involvement as well as units with vibrant spouses' clubs. Interestingly, in the US Air Force, 'spouse training' is offered to the spouses of newly appointed squadron commanders. Commander positions are demanding both on and off the job and commanders can expect to deal with a variety of issues that may include home life problems of their unit members. Training is provided to spouses to prepare them for the blurred demarcation of work life and home life as is common with squadron commanders.

In summary, Moskos' institutional/occupational model presents variables illustration aspects of military society. With both a Huntington style institutional military and a Janowitz style occupational military, the variables provided some of spectrum of US military practices by variable. Generally, the US military appeared to be closer to the institutional model, but society is dynamic and the US military has been in social change (Margiotta, 2019). It is generally reported that the US military is progressively moving from an institution to an occupation (Caforio & Nuciari, 2018), a claim the author generally supports based on their experience. In addition to society, some discussion on military culture will be presented next.

Themes in US military culture

Military society was examined through Moskos' I/O lens, but it is also useful to examine elements of military culture. Hofstede's view of culture as a type of "software of the mind" is a useful one and culture will be defined as the values, behaviors, norms, habits and beliefs of a group of people (Hofstede, 2001; Hofstede & Hofstede, 2005). There are several authors who have written on military culture (Burk, 1999; Lang, 1965; Soeters, 2000, 2018; Soeters, Winslow, & Weibull, 2006; P. H. Wilson, 2008) but Joseph Soeters' and James Burk's summary descriptions contain most elements. Soeters (2018)describes military culture with elements including discipline, hierarchy and rules, community life, Janus-faced, and assessment aversion. Burk (1999) identifies some of these elements of military culture but also includes ceremonies and etiquette, cohesion and Esprit de corps. A merged set of elements will be presented.

Military culture is heavily imbued with hierarchy and rules. Section 2.1.1 previously described the hierarchal rank structure that places every US military member somewhere within the chain of command (Halbe, 2011). Military culture is heavily defined by rules, such as the Uniform Code of Military Justice already presented. In addition to this code, there are myriads of rules that apply to all aspects of military duties which go under various names such as manuals or operating instructions. The combination and extent of hierarchy and rules within military organizations have led them to be described as quintessential bureaucracies. Segal argues that Max Weber based his model for the ideal-type bureaucratic organization on the Prussian Army (Segal & Ender, 2008; Weber,

1978). The presence of rules and hierarchal enforcers of rules flows naturally to the next element of military culture, discipline.

Discipline, or simply the obeying of rules, is in almost every account of military culture and noted by Soeters as possibly the most defining element (Soeters, 2018). Soeters divides discipline into *functional* discipline and *ceremonial* discipline. Accorder to Soeters, functional discipline can used to describe the following of rules necessary for combat effectiveness. These could include the acquisition of standardized "drills and skills" or the following rules relate to safety or security. Burk adds that this type of discipline is essential to combat effectiveness. He argues that high levels of instruction such as repetitive drills move individual's actions from intentional to habit, and that habit is a useful way for soldiers to overcome their natural resistance to actions normally avoided, such as killing other humans (Burk, 1999; D. Grossman, 2014). Soeters also adds that the discipline heavy nature of the military can cause members to view compliance as more desirable than competence. Soeters references Davis (1948, p. 147) account that non-compliance can get one labelled as a "cultural misfit" who should be transferred to a position where they can cause no harm to others or the mission (Soeters, 2018, p. 255). Soester's description of ceremonial discipline includes group wise appearance and etiquette and additional description will be presented below with Burke's discussion on ceremonies.

Communal life is also a prevalent element of military culture. Previously introduced under the I/O topic of residence, military members that work together also often do other elements of life together. While situations in naval ships and overseas barracks are extreme examples of communal life, communal living is still a culture in state-side, non-combat settings. Almost every military installation has living facilities, a commissary, athletic facilities, dining facilities, and one can typically acquire any need without leaving post. Due to their heightened security, Soeters describes post living arrangements as not merely gated communities, but more of a type of a fortress or even housing on an island (Soeters, 2018).

Externally observable elements of military culture include ceremonies and etiquette. Soeters described the adherence to dress standards, saluting and marching with flags as ceremonial discipline (Soeters, 2018). Uniforms are possibly the most immediately visible element of miliary culture and

serve more than one purpose. Until the last century, brightly colored uniforms and flags functionally served to identify friend from foe on the battlefield. Today, although camouflage uniforms will be found on modern battlefields, the US military members still maintain more brightly colored uniforms for ceremonies and non-combat activities (McNeill, 1997). When uniform appearance couples with uniform movements such formation marching, a powerful sense of collective identity can develop (Burk, 1999, p. 1247). In the course of their military service, the author has marched in several military parades with over 4,000 other participants all wearing identical parade dress. Being identically dressed and stepping in time with a drum cadence with a mass of individuals has a powerful effect of minimizing feelings of individuality and replacing them with conceptions that one's identity is that of the whole, and that the whole is greater than the sum of its parts. Some (E. E. A. Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010; McNeill, 1997) suggested that military ceremonies can be used to address ignorance or control anxieties and the author agrees with this claim.

Etiquette is also an externally visible element of military culture and routinely demonstrated with actions such as saluting superior officers (McNeill 1995; Burk 2008). Etiquette helps reinforce the hierarchal nature of ranks as well as discipline. Etiquette is not only rendered between individuals, if any military member finds themselves outdoors at 5:00PM on any US military base they will hear the bugle call retreat as the flag is lowered from the pole. The trained response is to stop walking, come to attention, face the closest flagpole, and render a salute until the conclusion of the music. Any motorist that is driving on base will stop their car during retreat as an act of respect to the US flag.

Not only do Burk and Soeters agree that ceremonies and etiquette fulfil certain functions within a military society, they propose that uniforms, flags and rituals provide soldiers with a solidarity and collective identity that is useful in establishing framework for mentally dealing with the harsh realities of death and destruction associated with combat (Burk, 1999, p. 1247; Soeters, 2018). Most military members will have to process the loss of a unit member at some point in their military service.

Connected to solidarity are the aspects of cohesion and esprit de corps in military culture. C*ohesion* is described as the close knit feelings of comradeship and shared identity that a soldier has

with the members in their immediate military unit (Burk, 1999) Cohesion is often established through concrete and primary experiences such as military drill or other experiences the members experience share with each other (McNeill, 1997). Burk uses *esprit de corps* to described a secondary commitment to the larger military establishment or nation to which a soldier's unit might belong. Burk argues that cohesion and esprit de corps are the primary influencers of unit morale and that the morale is directly linked to unit effectiveness (Burk, 1999). The importance of cohesion and esprit de corps on explaining a soldier's willingness to fight was documented as early as the turn of the twentieth century and initial conceptions were that soldiers fought for political ideology or nationalism (Bradford, 2009). Shils and Janowitz debunked this idea with their study of the German Wehrmacht near the end of World War II (Shils & Janowitz, 1948) and discovered that small unit cohesion, as opposed to their commitments to Nazism or a larger military organization, was far more significant in explaining why soldiers continued to fight. Interestingly, soldiers report their willingness to take part in violence is motived more by a desire to protect those in the fox hole next to them than for the flag they wear on their uniform (Pawiński & Chami, 2019).

Second to last to mention is Soeter's Janus-faced description of military culture. A Janus-faced military culture is described with having a hot face and cold face based on its current mission. The hot face refers to a culture assumed by members when immersed in a combat zone (Soeters, 2018). A culture of decisiveness, flexibly, courage, initiative, and generally a "can-do" approached is valued due to its utility on a battlefield (Andersson et al., 2015; Soeters, 2018, p. 256). While this hot approach is functional in winning wars, it can empower a setting where individuals can make ethical compromises in pursuit of winning (Emonet, 2018; Karpinski & Strasser, 2005). Oppositely, the Janus cold face represents military culture during times of peace. A cold faced culture is typified by non-combat operations such as training, preparing and practicing and in these settings commanders act more like managers in civilian organizations (Soeters, 2018). A cold culture might fall victim to an increased emphasis on activities such as polishing combat boots to mirror-like finishes, that have no apparently military utility. Because conflicts start and end, a Janus-faced culture is dynamic in the military. As military members deploy and re-deploy from combat zones they will be required to shift

back and forth between a hot and cold cultures. The research questions will investigate military members currently at cold faced cultures at the US military service academies.

Soeter's final description of military culture includes his idea that the military is averse to outside assessment (Soeters, 2018, p. 257). His argument follows that, like clergymen and medical doctors, military members hold a belief that they operate at a unique and sacred intersection of life and death, and therefore should be exempted from criticisms by outsiders (Cohn, 2015; Soeters, 2018). It is possible that an aversion to external assessment is reinforced by military societal elements such as having a separate law and living in seclusion from the rest of civilian society.

Subcultures within the military

It would be simplistic to assume that the cultural elements described are uniformly expressed across all military society. Subcultures exist within the millions of US military members and discussion of a few subcultures will provide relevance when answering research questions (Griffith, 2011; Kümmel, 2018). Perhaps due to the different nature of their missions, some of the most readily apparent military subcultures exist with the different services described in section 2.1.1. For example, a closer examination of communal life will reveal differences between the US Air Force and US Navy. US Navy service members will spend significant portions of their military careers living aboard a naval vessel in extremely tight living quarters. Sub-mariners even employ the space saving practice of hot bunking. Hot bunking is a practice where 3 members share a single sleeping berth in succession and every 8 hours a still warm sleeping birth is handed over to the next occupant. Due to concerns that the close confines of naval vessels will lead to undesired fraternization issues, Navy service members of different ranks generally do not socialize during non-duty hours and senior, mid-level, and junior officers each have their own separate dining facilities aboard the large naval vessels. Conversely, US Air Force bases typically have minimal limits on physical space and an aircraft's ability to rapidly travel long distances means AF members can commute thousands of miles to a battlefield and then return home to spend the night with their families.

Subcultures can also easily exist within a single service as Wilson (1989) documented with his three cultures of the US Navy. He described the "black shoe" Navy, composed of service members

stationed on traditional warships like cruisers and destroyers. There is also the "blown shoe" Navy composed of Naval aviators and their aircraft carriers. Finally, Wilson described the "felt shoe" navy for those serving on submarines who wear cloth shoes to avoid making any sounds and compromising their submarine's location to sensitive undersea listening equipment (J. Q. Wilson, 1989, p. 106).

Service subcultures can also differ along elements like the Janus-Faced element. Possibly due to the closer proximity to physical danger, units within the US Army and Marine Corps probably represent some of the most *hot* faced military services. Conversely, support units withing the US Space Force and Air Force will generally be in a *cold* faced posture due to the remote nature of conflict (Brooks, 2024). Controlling satellites from computer terminals located in mountain bases in one's home country appears to be a different battlefield than those located in foreign nations. The US service academies would be considered a cold faced subculture and literature on the service academies will be presented next.

2.1.3 **The US military service academies**

Previous sections in this chapter have examined the military purpose and structure (2.1.1) as well as military society and culture (2.1.2). This section will discuss the US military service academies what limited literature is available on science teachers and their pedagogical beliefs with in.

The US military service academies are schools of higher education that provide a 4-year bachelors of science degree in a liberal arts model (Kaufmann Jr, 2015; Simons, 1966). These academies are funded and operated by the US military their primary purpose is to prepare and commission officers for military service. As previously presented in Table 3, all US military officers are required to possess at least a four-year bachelor's degree so to maintain a stable supply officer corps the US military must commission approximately 17,000 new officers annually. Although US military service academies have existed for over 200 years (Born, Phillips, & Trainor, 2012), demand for officers increased during World War II and at present ~18% of officers obtaining their bachelor's degrees at a US military service academy while the rest obtain their degrees at civilian universities or colleges (U.S. Government Accountability Office, 2003). The five US military service academies are

located across the US with the United States Air Force Academy in Colorado Springs, the United States Military Academy at West Point, the United States Naval Academy in Annapolis, the United States Coast Guard Academy in New London and the United States Merchant Marine Academy in Kings Point. The three largest academies serving the US armed forces are the Air Force, Army, and Naval academies which supply officers for the combatant functions of the military. This study will be focused on these three academies as their size and education is somewhat different from the remaining two.

The course of instruction at the US military academies generally follows the American style liberal arts college and a student will receive a general and broad curriculum in addition to focus in one of 25-45 accredited academic degrees (Cayetano, 2015). Liberal arts colleges in the US traditionally have an element of developing a 'whole person' concept (Van der Wende, 2017) and each service academy has its own set of core values designed to develop character (Hajjar, 2014). In addition to core values, the service academies include a core curriculum that includes a broad variety of classes that all students are required to complete. The rational for this type of education is articulated by the US Navy Academy:

> *"The foundation of that education is a core curriculum that prepares each graduate for service as a junior officer in the naval operating forces. Beyond that, midshipmen choose an academic major reflecting their interests and abilities, as well as the needs of the naval service. Together, the academic core and the majors program help provide our nation with well-rounded, well-educated officers able to lead the nation's Navy and Marine Corps in the 21st century." (United States Naval Academy, 2015, p. 3)*

The Navy supports the belief that a well-rounded education is necessary for junior naval officers. The core curriculum composes approximately two-thirds of the required semester hours for students (United States Air Force Academy, 2019, p. 36). Courses in science are a required portion of every student's program and each student will typically receive one year of both physics and chemistry classes. Class sizes are purposefully small and typically 20-24 students are in a core subject class (United States Air Force Academy, 2019, p. 52).

Gaining admission to a US military service academy is highly competitive process and follows some non-traditional practices in higher education admission. Admissions are not based solely on academic performance, but rather a whole person evaluation (Cayetano, 2015; Forest, 2003).

As part of the admissions process, applicants must complete athletics tests, medical screening tests, and should have demonstrated leadership ability through extracurricular activities (U.S. Government Accountability Office, 2003). Additionally, vacancies are distributed across the US by congressional district and candidates must compete for nominations from their local congressional members to apply to a US military service academy.

Unlike liberal arts colleges in a civilian setting, US military service academies are highly structured where nearly every aspect of a student's life is controlled (Born et al., 2012). In returning to military society as an institution, service academies could be classified as a *total institution* (Goffman, 1961). This term developed by Goffman was reserved for the most extreme institutions such as prisons, psychiatric hospitals and military barracks where residence and work were synonymous and individuals are cut off from society and lead enclosed and formally administered lives (Davies, 1989; Goffman, 1961, p. 20).

Another non-traditional feature of the military service academies is that between 50% to 60% of the academic faculty are active-duty military personnel (Keller, Lim, Harrington, O'Neill, & Haddad, 2013). Most of these military instructors are teaching on a 3-year career-broadening assignment different from their regular military profession and will return to their previous duties at the completion of their teaching assignment (Swaim, 2017). While literature does exist on the general nature of the US service academies, there remains large gaps in knowledge. It costs US taxpayers approximately $500,000 to produce a single service academy graduate and they are accountable to the US Congress. Accordingly there is an abundance grey literature on the service academies and their performance (United States Air Force Academy, 2015). The service academies occasionally draw criticism for their return on investment in addition to being the subject of local and national news in the event of any scandal (Karakurumer, 2010; Malmstrom & Mullin, 2013; Rosenstein, Angelis, McCone, & Carroll, 2018). There is a lack of peer reviewed literature focused on the US service academies and pedagogically focused literature is almost non-existent. Searches of Educational Resources Information Center (ERIC), Web of Science, SCOPUS, internet searches, as well as searching US service academy library listings did not reveal any literature exploring the pedagogic beliefs and practices of science teachers.

The majority of peer reviewed literature produced at or about the service academies is focused on non-pedagogical topics (Barry, 2010, 2016; White, 2006). While service academy instructors do publish in order to advance in academic rank, the vast majority do so on topics in their field of study. Only a minority of those academic publications have focused on educational research employed at the service academies. Examples include implementation of Novak's (2011) just-in-time-teaching and Cayetano's (2015) comparative study of the service academies accreditation process and demographics. The most closely related publication to teachers' pedagogical beliefs was Swaim's (2017) study that focused on the transition of military members from operational Air Force roles to that of academic instructors at the US Air Force Academy. The study provided a useful description of the teacher training offered to new teachers through a case study of four instructor in their first-year teaching. The study does not include descriptions of the teacher training offered at the Army or Naval Academy. Studies on the beliefs of science teachers (Abd-El-Khalick, Bell, & Lederman, 1998; Brickhouse, 1989; Hewson & Hewson, 1987; Prosser et al., 1994) which placed those beliefs along the spectrum of teacher-student spectrum does not exist in a military context. A conceptual frame work exploring teachers' pedagogical beliefs and practices will be presented next.

2.2 Conceptual framework: pedagogical beliefs and practices

Section 2.1 presented a description of the US military as the setting for this research. Section 2.2 transitions to describing the conceptual framework of teachers' beliefs and teachers' practices that will be the focus of this study. Section 2.2.1 discusses literature on the nature of teachers' beliefs, how they form and change, some specific topics of teachers' beliefs, and the consistencies and inconsistencies on how they relate to teachers' practices. Section 2.2.2 presents literature describing teachers' practices focusing on areas of constructivist versus traditional practices. The discussion of the military setting and teachers' beliefs and practices prepares the reader for the presentation of the research questions in section 2.3.

2.2.1 Teachers' beliefs

Researchers have been studying and writing on teachers' beliefs for at least 70 years (Oliver, 1953). It appears that a driving reason for the study of a teacher's beliefs is a hope articulated by

Pajares (1992, p. 307) that “beliefs are the best indicators of the decisions individuals make throughout their lives”. This driving reason laid out by Pajares and others (Bandura, 1986; Dewey, 2022; Rokeach, 1968) can be combined with a few more assumptions to make a causal chain. First, that teachers hold beliefs about their teaching. Next, that these teachers’ beliefs influence and predict teachers’ teaching practices in the classroom. Finally, there is the assumption that teachers’ practices in the classroom affect student outcomes. In accordance with these assumptions, if one wanted to change student outcomes, one might accomplish this through changing the beliefs that teachers hold about teaching. Literature that focuses on the study of teachers’ beliefs generally seeks to explain some small element of the causal chain above, but the topic of beliefs is far from easily understood.

While belief is a common word in the vernacular, it is a more complicated concept in the research literature and a singular definition of teachers’ beliefs does not exist. Pajares (1992, p. 309) rightly describes them as a “messy construct” and cites a list of terms that have been used in their place including: attitudes, values, judgments, opinions, ideology, perceptions, conceptions, conceptual systems, dispositions, theories, and internal mental processes to mention just a few. Pajares set out to explore this messy construct over 30 years ago but a common definition for teachers’ beliefs among scholars has yet to emerge. Earlier definitions sought to define beliefs by highlighting their differences from knowledge. In those definitions knowledge is typically based on evidence while beliefs are formed in many ways and generally not reliant on evidence (Abelson, 1979; Calderhead, 1996; Pajares, 1992). This suggests that beliefs are a an individually held conception and Kagan (1992, p. 65) builds upon this idea describing teachers’ beliefs as “tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught.” This adds to the idea that beliefs do not have to be true and adds a proposition that beliefs might even be unknown by or accessible to the teacher holding them. Mansour’s (2009, p. 26) definition states that beliefs “characterize a teacher’s idiosyncratic unity of thought about objects, people, events and their characteristic relationships that affect his/her planning and interactive thoughts and decisions.” This definition suggests that beliefs have relationships with other beliefs and that the sum of them can affect decisions. Each definition focuses on different elements and a consensus has yet to be achieved. Teachers’ beliefs as a psychological construct are a complicated and nebulous construct. To create a

functional framework for answering the research questions of this study, literature on several aspects of teachers' beliefs will be discussed including: ideas on the nature of teachers' beliefs, what teacher's hold beliefs about, how they connect to teachers' practices and how or if teachers' beliefs change.

The nature of teachers' beliefs: themes from the literature

Influential reviews of literature on teachers' beliefs (Fang, 1996; Fives & Buehl, 2012; Kagan, 1992; Mansour, 2009; Pajares, 1992; Thompson, 1992) and science teachers' beliefs (Bryan, 2012; Jones & Carter, 2013) reveal that a majority of articles focus on teachers' beliefs about specific topics such as subject area knowledge, pedagogy, development, identity, schools, and influence of context. Before these subject topics are discussed, common themes in the literature that describe the nature of teachers' beliefs will be explored. While every review presents some discussion on the nature of teachers' beliefs, Fives and Buehl's (2012) examination provides a comprehensive and useful description of the nature of teachers' beliefs. Their review describes beliefs with five categories including (1) their implicit and explicit nature, (2) their stability over time, (3) whether they are situational or generalizable in nature, (4) their relation to knowledge, and finally (5) their existence as stand-alone units or as part of a larger belief system (Fives & Buehl, 2012).

The implicit nature of teachers' beliefs has already been referenced above (Kagan, 1992; Richardson, 1996) and some researchers hold that teachers may be unaware of their beliefs or are unable to articulate them. This supports Pajares' claim that beliefs do not lend themselves easily to empirical investigation (Pajares, 1992, p. 308). One approach researchers have taken to studying beliefs is to not attempt to study the belief directly but rather focus on observing teachers' practices (section 2.2.2) and making inferences back to teachers' beliefs (Fang, 1996). The implicit nature of beliefs is not an assumption held by all and the methods employed in studying teachers' beliefs imply that many researchers assume that beliefs are explicit and that teachers are able to communicate them. This is demonstrated by the numerous studies that utilize methods including surveys or questionnaires where instructors are asked to report their beliefs directly (Ho, Watkins, & Kelly, 2001; Johnston, 1996; Luft & Roehrig, 2007). Fives and Buehl (2012) present a more balanced view that teachers

likely hold a multitude of beliefs including implicit beliefs, explicit beliefs, and likely a number of beliefs somewhere between to the two positions.

The second common attribute used in describing the nature of teachers' beliefs is their stability with time or new experience. One position is that beliefs are relatively stable and are generally resistant to change over time (Bryan, 2003; Kagan, 1992; Posner, Strike, Hewson, & Gertzog, 1982). In his synthesis, Pajares' first conclusion is that beliefs "are formed early and tend to self-perpetuate, persevering even against contradictions caused by reason, time, schooling, or experience" (Pajares, 1992, p. 324). A stable view of beliefs would introduce difficultly for those seeking to change student outcomes by changing teachers' beliefs. Indeed, studies designed to change beliefs utilizing interventions (Haney & McArthur, 2002; Nettle, 1998) discovered that certain teachers' beliefs remained stable despite the efforts of the intervention. Reasons for explaining stability include how long various teachers' beliefs have been held by the teacher as well as how interconnected certain beliefs are to other beliefs held by teachers (Ertmer & Ottenbreit-Leftwich, 2010; Richardson, 1996). Although certain beliefs appear resistant to change, others (Bandura, 1997; Fives & Buehl, 2012; Simmons et al., 1999; Thompson, 1992) hold a dynamic view of teachers' beliefs and that beliefs change with new experiences or reflective self-examination. Others (Levin & Wadmany, 2005; Tondeur, Van Braak, Ertmer, & Ottenbreit-Leftwich, 2017) report that changes in beliefs only occurred with long term programs, some up to three years. Clarke and Hollingsworth (2002) also propose that beliefs are changed by first changing practices in professional development programs. Others (Nespor, 1987, p. 321) suggest that a certain magnitude experience, such as a dramatic gestalt shift, was required to unseat entrenched beliefs. Again, the likely nature of teachers' beliefs is that some are more stable than others and that there are a variety of factors that contribute to a belief's stability.

The third nature of teachers' beliefs focuses on how, or if, beliefs are situationally or contextually specific. Situation specific nature is presented different from stability in that it is focused around the idea that certain teachers' beliefs might be activated by contextual demands, as opposed to being generalizable across many settings (Fives & Gill, 2014). The less common view in the literature, such as held by Kagan (1992, p. 66), holds that teachers' beliefs are generalizable and

congruent across different classes and grade levels. But others (Fang, 1996; Lumpe, Haney, & Czerniak, 2000; Mansour, 2008; Radford, 2008) hold to a more cultural base for teachers' beliefs and argue for the centrality of understanding context when examining beliefs (Bandura, 1977).

The fourth nature of teachers' beliefs is found more often in older literature on teachers' beliefs and pertains to the connections and distinctions between knowledge and beliefs**.** Early on (Abelson, 1979) attention was given to articulating how beliefs were different from knowledge. Generalized distinctions (Clandinin & Connelly, 1987) indicated that beliefs were different from knowledge in that beliefs were based on opinion or preference while knowledge was based on some element of truth. Pajares notes that in many studies "it was difficult to pinpoint where knowledge ended and belief began" with the effect that sometimes the words were used interchangeably (Pajares, 1992, p. 309). As many of the difference between knowledge and beliefs generally involved their different functions, additional discussion will be presented below in the paragraph on the function of beliefs.

The final commonly expressed nature of teachers' beliefs is that their existence is not isolated, but that they are part of belief systems (Rokeach, 1968). Belief systems have been defined as hierarchal structures of beliefs with central or core beliefs at the top influencing newer or less central beliefs (Abelson, 1979; Rokeach, 1968). One interesting idea put forth by Bryan (2003) is that more than one system of beliefs, or in Bryan's term nests of beliefs, might exist in a teacher and these systems can be in direct conflict with each other. The existence of multiple systems might be an explanation for the contextual nature of beliefs. Different belief systems held by instructors might be activated in different contexts (Lumpe et al., 2000; Norton, Richardson, Hartley, Newstead, & Mayes, 2005). The system nature of beliefs might also explain differences in stability of certain beliefs about teaching. If beliefs about teaching come into conflict with more centrally held beliefs, such as beliefs about religion (Mansour, 2008), the less central beliefs might be more subject to change.

With the various aspects of the nature of beliefs presented, it is also useful to examine current ideas on the function of beliefs. In their review of teachers' beliefs literature, Fives and Buehl (2012) propose that beliefs act as filters for interpreting new information or experiences, as frameworks for making decisions, and as guides for planning actions or practices. While these three functions share

similarities with initially held assumptions about beliefs and their impact on student outcomes, the claims are less strong. As filters, teachers' beliefs filter new information and experiences and allow those that align with existing beliefs through. This is not a new attribute of belief and in referencing the work of Nespor (1987), Pajares describes teachers' beliefs as applying encoding and decoding bias to information and decision making (1992, p. 317). This has also been described as confirmation bias (Nickerson, 1998; Nisbett & Ross, 1980). In addition to filtering, it is also proposed that teachers' beliefs affect the way teachers frame and reframe problems. Enyedy et al (2006) describe a teacher who reframes their lack pedagogical content knowledge with inquiry focused beliefs. In their study, a teacher reframes their original problem of a lack of knowledge to a new opportunity to position themselves alongside students as co-inquirers in the classroom. After reframing, it is finally proposed that teachers' beliefs function to guide plans of action. Teachers' beliefs guiding plans of actions is a much weaker claim than beliefs predicting practices but it still illustrates the most contested claim within teachers' belief literature, and the topic of the next section. Is there congruence or incongruence between teachers' beliefs and teachers' practices?

Consistency versus inconsistency: links between teachers' beliefs and practices

The most contested argument within teachers' beliefs literature is whether or not teachers' beliefs are consistent with their practices (Buehl & Beck, 2014; Fang, 1996; Mansour, 2009, 2013; Tondeur et al., 2017). The traditional view is that teachers' beliefs are consistent with teachers' practices. Building from the work of others (Bandura, 1986; Dewey, 2022; Nisbett & Ross, 1980; Rokeach, 1968) Pajares (1992, pp. 307, 329) proposed that "beliefs are the best indicators of the decisions individuals make" and predicted that the study of teachers' beliefs would become the most important construct in the field. Other reviews of teachers' beliefs literature (Kagan, 1992) also supported this position. The claim that teachers' beliefs held the greatest statistical influence over teacher actions was supported with Haney, Czerniak and Lumpe's (1996) large sample quantitative studies of science teachers. The consistency position was also supported by descriptive qualitative studies of science teachers' beliefs such as the one by Luft (1999). Luft claimed that presence of specific teachers' beliefs about problem solving strategies developed during an in-service teacher

development program caused the implementation of corresponding problem-solving practice in the classroom. Theoretically, the consistency position might be preferred because it provides one additional way in which to affect student outcomes.

But while many researchers support the consistency position, there are many others that argue that there is a lack of adequate evidence for such a claim. Kane, Sandretto and Heath's (2002) critical review of the consistency position argues that there are several reasons why the causal connection is not supported with evidence. One reason is that the methods utilized to document beliefs in many studies are inappropriate or flawed and that researchers often use self-reported beliefs and self-reported practices (Kane et al., 2002). This addresses the explicit and implicit nature of beliefs. As beliefs are impossible to directly measure, they must be observed indirectly through instructor self-reports or interpreted from observing teacher's practices. Additionally, rather than observing teachers' practices directly, researchers also use self-reporting methods to measure teachers' practices. The inconsistency position is also supported by Stipek and Byler (1997) who reported in their study that certain teachers failed to report their true beliefs because they either felt they didn't have the freedom or they wanted to provide the expected answer to researchers. Other reviews (Fives & Buehl, 2012) reported that in several studies, instructors reported holding certain beliefs, such as constructivist beliefs about teaching, but upon examination actually described beliefs that would be considered as traditional in nature. Fives and Buehl (2012) concluded that the differences were likely due to a lack of understanding in the constructivist and traditional theories. Another common theme in explaining the inconsistent position is that it is possible that certain teachers' beliefs might hold a pedagogical belief that they are not able to carry out in practice due to external controlling factors like school policies or constraints (Fang, 1996; Keys, 2005) or cultural norms (Kwon, 2004; Mansour, 2008). While consistency or inconsistency remains contested, a common conclusion is that the relationship between teachers' beliefs and teachers' practices is complicated and requires more study (Fives & Buehl, 2012; Kane et al., 2002; Mansour, 2013; Tondeur et al., 2017).

Teachers' beliefs about specific topics

The previous section presented the literature on the nature of teachers' beliefs, but more literature exists on the specific topics that teachers hold beliefs about. Many topics exist and organizing them into themes is difficult as several themes appear to overlap, but Fives and Buehl (2012) group categories of teacher beliefs into themes on 1) self, 2) context or environment 3) content or knowledge 4) specific teaching practices 5) teaching approaches, and 6) students. Literature in these topics will be presented with emphasis given to the ones considered more applicable to this study.

Teachers' beliefs about self and identity

Literature on teachers' beliefs about self includes beliefs about their role as a teacher (Bryan, 2003; Hanson, 2013; Mansour, 2008; Simmons et al., 1999), their self-efficacy (Knoblauch & Hoy, 2008; Moseley, Reinke, & Bookout, 2002; Pajares, 2003; J. C. Park, Chu, & Martin, 2016) and most relevant to this study, their teacher identity (Avraamidou, 2014; Beijaard, Meijer, & Verloop, 2004; Beijaard, Verloop, & Vermunt, 2000; Gee, 2000; Izadinia, 2013; Mansour, 2008). Teachers' beliefs about their identity can be described by Beijaard's (2004, p. 108) question, "who am I at this moment?'' This question of self-perception has an added element of self-perception at a specific times and places. As time is dynamic this definition suggests a dynamic element to teachers' beliefs about their identity. Wenger (2000, p. 239) builds on this idea and proposes that teachers frame the answers to their identity while situated in communities they are members of and that as they move from community to community, they carry elements of previous communities into the new ones. Avraamidou' s (2014) review concludes that teachers beliefs about identity are a) socially constructed and constituted b) dynamic, fluid, and under constant revision c) complex and multifaceted with tiered and interrelated sub-identities. Alternatively, Gee (2000) developed four ways of viewing identity based on nature, institution, discourse, and affinity. Institutional identity, which Gee suggests is authorized by authorities, is an immensely useful lens from which to exam the beliefs teachers hold about themselves in military institutions. Other themes in beliefs about teacher identity are connected to religious or cultural identities (Mansour, 2008; Vågan, 2011) and storytelling (Connelly &

Clandinin, 1999). As previously mentioned, some topics on teachers' beliefs seem to fall into more than one category such as teachers having an inquiry identity (Bryce, Wilmes, & Bellino, 2016) or a professional development identity (Enyedy et al., 2006). Another theme in teachers beliefs about their identity, and hinted at in the definition, is teacher beliefs about self in different contexts (Gilmore & Kramer, 2019; E. C. Wenger & Snyder, 2000). Just as beliefs about self are framed by context, the next section presents literature on how many teachers beliefs are framed by their context or environment.

Teachers' beliefs about their context or environment

Fives and Buehl's (2012) second category of teachers beliefs focus on context or environment and includes teachers beliefs about school culture or climate and teachers beliefs about their relationship with co-workers. Similar to beliefs on self, a common theme in the literature is that teachers beliefs about most things related to teaching are influenced by their beliefs about the context or environment (B. Levin & He, 2008; Mansour, 2009, 2013; Tobin, Tippins, & Gallard, 1994). This idea was previously proposed as an explanation for the inconsistency between teachers' beliefs and practices (Kane et al., 2002). Teaching context can be more specifically described as school culture. Talbert and McLaughlin (1992) propose that culture is composed of, among other thing, school policies, curricula, goals and teachers beliefs and these have been explored (Cronin-Jones, 1991; Czerniak & Lumpe, 1996; Forbes & Davis, 2008; Haney et al., 1996; Mansour, 2010; McIntosh & Zeidler, 1988). While an entire school could be considered a culture, the idea that a specific subject within a school could also be its own culture has been presented (Grossman & Stodolsky, 1995). These ideas about culture are particularly relevant to the research questions that are not only set in a military culture, but three different subcultures at three different military schools. The next section investigates teachers' beliefs about specific content or knowledge, a popular theme in the literature.

Teachers' beliefs about content or knowledge, specific and general teaching approaches, and students

Teachers' beliefs about content or knowledge includes their beliefs about topics such as the nature of science (Akerson, Abd-El-Khalick, & Lederman, 2000; Dagher & Erduran, 2016;

Lederman, 1999) pedagogical content knowledge (Meschede, Fiebranz, Möller, & Steffensky, 2017; S. Park & Oliver, 2008; Peterson, Fennema, Carpenter, & Loef, 1989), chemistry (Al-Amoush, Usak, Erdogan, Markic, & Eilks, 2013; Cheung, 2011; Uzuntiryaki & Boz, 2007; Veal, 2004) physics (Krumphals, Hopf, & Haagen-Schützenhöfer, 2019; Siorenta & Jimoyiannis, 2008) and teaching science (Luft, 1999). While popular within the literature on teacher's belief, there is less application of these topics to this study. Teachers hold beliefs about specific teaching practices such as cooperative learning , (Ghaith, 2018; Gillies & Boyle, 2010; Lumpe, Haney, & Czerniak, 1998), inquiry (Crawford, 2007; Luft, 2001; Wallace & Kang, 2004), and laboratories (Kang & Wallace, 2005; Siorenta & Jimoyiannis, 2008). Some literature focuses on teachers' beliefs about specific teaching practices but the literature also addresses teachers' beliefs about various general or holistic teaching approaches. A common theme in the literatures are the differences in beliefs about traditional or transmission based approaches and those of constructivist approaches (Beck, Czerniak, & Lumpe, 2000; Friedrichsen, Driel, & Abell, 2011; Haney, Lumpe, & Czerniak, 2003; Haney & McArthur, 2002; Kember, 1997; Samuelowicz & Bain, 2001; Savasci & Berlin, 2012; Tsai, 2002). These two beliefs systems have also been described with Kember's (1997, p. 255) description of "teacher-centered/content-oriented" and "student-centered/learning-oriented" views. Finaly, teachers also hold beliefs about students which include beliefs about student engagement and learning (Beswick, 2005; Bryan, 2003; Turner, Christensen, & Meyer, 2009).

This concludes a discussion of nature of teachers' pedagogical beliefs, some of the various topics that teachers hold pedagogical beliefs about, and the central argument of consistency or inconsistency. It has been noted (Fives & Buehl, 2012) that since it is difficult to understanding the links between teacher's pedagogical beliefs and their practices, one solution is to simply bypass the topic and instead just solely focus on the instructors' teaching practice in the classroom, which is the topic of the next section.

2.2.2 **Teachers' practices**

This section explores some of the literature on teachers' practices. It presents a description of traditional teaching practices and progressive, or constructivist, teaching practices. Some of the claims

of constructivist practices are presented along with difficulties in changing teachers' practices. Teachers' practices will be defined with Buehl and Beck's (2014) description of any action that is part of the teaching process. This could include both actions in and out of the classroom and examples could be an array of specific teaching strategies, assessment, planning, and even practices related teaching in community with other teachers. The scope and topics found in literature on teachers' practices include many similarities with those found in the literature on teachers' beliefs and sometimes the distinction between beliefs versus practices is difficult to determine. The rationale for the study of teachers' practices follows similar logic to the study of beliefs, if different practices that teachers do in the classroom can lead to different student outcomes, then by changing teacher practices we can continue to improve student outcomes.

The teacher practices deemed as traditional generally describe practices that follow a teacher-centered or content-oriented philosophy (Kember, 1997; Mascolo, 2009). Traditional teaching practices elevate the holder of the knowledge in the classroom and knowledge is described as flowing in a one-way direction from the teacher to student (Bligh, 1998). In traditional models, the teacher is the one reported as being active while the student is often described as being a passive learner (Zukin & Snyder, 1984). While it might seem that there are several traditional teaching practices, the term appears to be almost exclusively used to describe the single didactic approach of the lecture (Handelsman et al., 2004; National Research Council, 2012; Nichols & Miller, 1994; Reiser & Dempsey, 2012; Wieman, 2014). Despite the critical views of lectures they remain a very common teaching practice in higher education and they are an effective way of transferring information especially considering they are not limited by the size of the audience and they scale efficiently and economically (Bligh, 1998; Brookfield, 1990; Mazur, 2009).

Traditional teaching practices are typically set in contrast to constructivist teaching practices. Constructivism has been described as a philosophy, an epistemology, a cognitive position, and a pedagogical orientation (Noddings, 2018, p. 126). Generally, constructivist teaching practices attempt to create environments where students build up, or construct, their knowledge through engaged activity (Piaget, 1926; Scaife, 2012, p. 81). While sometimes termed active learning practices there appears to be many types of constructivist teaching practices (Baeten, Kyndt, Struyven, & Dochy,

2010; Martin, Prosser, Trigwell, Ramsden, & Benjamin, 2000). A general claim of proponents of these teaching practices is a that they have shifted the individual who is doing the activity from the teacher to the student (Kember, 1997; Mazur, 2009; Michael, 2006). Numerous smaller studies have claimed that active learning methods have been associated with increased efficacy over traditional methods (Blanchard et al., 2010; Deslauriers, Schelew, & Wieman, 2011; Fagen & Crouch, 2002; Handelsman et al., 2004; Knight & Wood, 2005; Lasry, Mazur, & Watkins, 2008; Michael, 2006; Prince, 2004; Smith et al., 2009; Wieman, 2014; Wood, 2009). Freeman et al. (2014) in a meta-analysis study reviewed 255 peer reviewed studies comparing lecturing with various active learning teaching practices and found that overall, the use of active learning instructional practices increased student attainment while decreasing failure rates. Hake (1998) in a large-N study surveyed over 6,500 students in 62 different classes and claimed that classes employing active learning practices achieved gains of two standard deviations over traditional classes. But there is also literature that claims that active learning-based interventions didn't yield the promised increases in student learning. Kirschner et al. (2006) found that constructivist practices that support shifting activity from teachers to students could be taken too far. These minimal guidance teaching practices were reported as failing when students were unable to construct their own understanding as they lacked certain underpinning knowledge or that they needed more guidance and engagement by teachers. It also appears to be an assumption that active learning is something that requires an external component of activity. If active learning is something that occurs in the mind, it seems possible to have a motionless student who is fully engaged and learning in an active mental state during a lecture.

Constructivist teaching practices

Moving on from the claim that constructivist or active learning practices are superior, it is useful to describe some of the many different types of practices that occur. One active learning practice requiring the least amount of change from traditional methods is by introducing elements that require student engagement during traditional lectures. While one of the simplest ways of making lectures more engaging is through asking questions. Technology and the use of individual response clickers has allowed the near infinite scaling of question asking as every student in a class has an

opportunity to engage (Deslauriers et al., 2011; Fagen & Crouch, 2002; Freeman et al., 2014; M. K. Smith et al., 2009). Another active learning practices is through the use of flipped classroom. In this practice students prepare for class by watching pre-recorded lectures or reading assignments and then use in class time for working problems with the facilitation of an instructors (Bergmann & Sams, 2012; Long, Cummins, & Waugh, 2017). Although not a new practice, the practice of including laboratory in science teaching activity is designed to increase active engagement (Hofstein, 2004; Redish, Saul, & Steinberg, 1997). Some active learning practices seek to increasing student activity through a social element and work to augment the learning relationship between student and teacher with that of a learning relationship between students. Examples of these practices include collaborative learning (Dragisich, Keller, & Zhao, 2016; Prince, 2004), peer-led team learning (Chan & Bauer, 2015), and peer-instruction (Deslauriers, Schelew, & Wieman, 2011; Fagen & Crouch, 2002; Freeman et al., 2014; M. K. Smith et al., 2009). Other active learning practices seek to increase student activity through the use of context to generate interesting questions or real-world problems. Some of practices include problem-based learning (Prince, 2004; K. A. Smith, Sheppard, Johnson, & Johnson, 2005), discovery learning, process-oriented guided inquiry learning (Moog & Spencer, 2008). Students can also be presented with context based learning practices where illustrations of content are selected from relevant contexts to the students (Woods, 2014). Although many constructivist teaching practices exist and there is evidence to suggest that these lead to increased learning, just as there is difficulty in getting teachers to change their belief, there is also difficulty in getting teachers to change their practices.

Difficulty in changing practices

Even though the literature suggests the increased efficacy of active learning methods (Freeman et al., 2014) and these practices have governmental support (National Research Council, 2012), many interventions seeking to increase the use of these practices are considered unsuccessful (Silverthorn, Thorn, & Svinicki, 2006; Stanford et al., 2017). Henderson, Beach, & Finkelstein (2011) analyzed the methods and efficacy of 191 interventions and noted that although 66.7% of articles claimed success, only 21.0% of studies actually provided strong evidence to support their claim.

Henderson, Beach, & Finkelstein's (2011) review concluded that the most successful interventions were ones that addressed the instructors beliefs, lasted over an extended period of time, and applied an appropriate understanding of the college as a complex system (Henderson et al., 2011; Neumann, Parry, & Becher, 2002). Their conclusions reach back to the belief-practice consistency claim and the formation of beliefs over time and in certain contexts. Barriers to practice change were also identified as: time constraints, inadequate resources, instructional challenges, loss of autonomy, conflict with institutional priorities and an unsupportive culture. Implementations that narrowly focused on only one aspect of change, such as distribution of best practices, often failed. These barriers have been identified in other studies can be broadly grouped into the two categories of issues dealing with instructor beliefs and instructional context (Bernstein-Sierra & Kezar, 2017; Brownell & Tanner, 2012; Henderson & Dancy, 2007; Schneckenberg, 2009; Shadle, Marker, & Earl, 2017) (Shadle, Marker, & Earl, 2017).

In summary, section 2.2 addressed both teachers' belief about education and their teaching practices. The nature of beliefs and practices involved elements of being contextual placed. When combined with the discussion of the military context in section 2.1 it is now possible to discuss the research questions of this study.

2.3 Research questions

The general aim of this study is to explore the undocumented science teachers' beliefs about education and their teaching practices in the atypical setting of US military higher education. Additionally, as more than one setting exists within military higher education exists, variations between the different settings and beliefs and practices discovered in them will be explored. These aims will be addressed through the development of three different research questions.

2.3.1 Teachers' beliefs about education and their teaching practices

In this study, teachers' beliefs about education are defined as teachers' educational beliefs associated with teaching see section 2.2.1. In agreement with literature (Pajares, 1992) a belief could be described as an attitude, value, judgment, perception, conception, theory (personal or general), practical principle, or perspective and is likely to be evaluative. This study is exploratory and can

include beliefs on the aims of teaching science, beliefs about teaching practices related to science, beliefs on student learning, beliefs on instructor education, beliefs on science teaching as an organized activity

A teaching practice is any action that teachers take part in that is part of the teaching process, see section 2.2.2. A spectrum of teaching practices related were explored and include the following types: teaching practice related to teaching science in the classroom, teaching practices associated with teacher's aims in teaching science, teaching practices related to instructor education, teaching practices related to science teaching as an organized activity. In the context of this study these are *reported* practices as no teacher observations were collected.

These descriptions provide the basis for the first research question "What are the beliefs about education and educational practices of science instructors at the US service academies?" Pedagogic practices are the second portion of the first research question. The second research question investigates possible sources of these beliefs and practices.

2.3.2 Influences on beliefs about education and teaching practices

Science teachers at the US military service academies hold beliefs about education and use various teaching practices. Literature on beliefs and practices suggests that both are influenced by contextual aspects such as culture, environment, school policy, time constraints, access to resources, organizational values, norms, and social pressures such as other teachers (Ertmer & Ottenbreit-Leftwich, 2010; B. Levin & He, 2008; Mansour, 2009, 2013; Richardson, 1996; Tobin et al., 1994). Investigating the influences on instructor's pedagogic beliefs and practices is the goal of the second research question "What are the reported influences on science instructors' pedagogic beliefs and practices?" The last research question investigates how the beliefs, practices and influences vary with different groups within the military.

2.3.3 Variance in belief, practice, and influence

This study is conducted in three different military settings, those of the US Army, US Navy and US Air Force. As each setting is different and contains its own military subculture, the last research question explores how the beliefs, practices and influences of instructors might vary between

different groups within the military. The topics above can be combined into three specific research questions for the study.

2.3.4 Specific research questions

Research Question 1: What are the reported beliefs about education and the teaching practices of science instructors at the US military service academies?

Research Question 2: What are the influences on science instructors' beliefs and practices at the US military service academies?

Research Question 3: How do the instructor beliefs and practices vary between different groups within the US the military?

In summary, chapter 2 presented literature on the purpose, structure and culture of the US military. It detailed the lack of educational literature produced about instructors and a gap in knowledge. It presented literature on teachers' beliefs about education and some of their practices. It finally combined these topics to produce a set of research questions asking what are the educational beliefs and practices of instructors, what is influencing those beliefs, and how do those beliefs vary in three different military settings. Chapter 3 presents the methods selected for answer those questions.

3 METHODS

Introduction to the chapter

This methodology chapter addresses how the research questions were operationalized and addressed in practice. Section 3.1 describes the overall methodological approach to the study. Section 3.2 discusses how the qualitative document and interview data were collected and analyzed. Section 3.3 follows with a discussion of how based on the qualitative findings a quantitative survey was developed. The chapter concludes with section 3.4 as a discussion of ethical considerations and limitations of the study.

3.1 Methods overview and researcher reflectivity and identity

This section outlines the overall approach and rational in answering the research questions. As the research questions guide the chapter, they are presented in Table 5 with additional detail as related to the overall methods of the study. The major portions of this chapter consist of detailing the specifics of Table 5. Section 3.1.1 explains the rational for a mixed method exploratory sequential design as an overall approach. Section 3.1.2 consists of a reflective discussion on how my assumptions and positionality influenced the study.

Table 5: Methods overview connecting research questions to phase, method, data, analysis, and output

Methods Overview			
Research Questions	Phase & Method	Nature & Analysis	Output
What are the reported beliefs about education and the teaching practices of science instructors at the US military service academies?	Phase 1 Documentary Research (N=7)	Qualitative & Grounded Theory	Interview/ Survey Input Data to answer RQs
What are the reported influences on science instructors' beliefs and practices?	Phase 2 Interviews (N=25) + Phase 3 Survey (N≈250)	Qualitative & Grounded Theory + Quantitative & Factor Analysis	Input to survey Data to answer RQs + Data to answer RQs
How do these beliefs and practices vary between groups in the military?			

3.1.1 Mixed methods and the exploratory sequential design

As discussed in sections 2.1 of the literature review, the field of science instructors' beliefs and reported practices in the US military service academies remained unexplored. Correspondingly, the research questions designed to investigate these beliefs about teaching and the reported practices sought to explore this field (Patton, 1990). Two qualitative methods, documentary analysis and semi-structured interviews, were combined with one quantitative method, a survey, making this research a mixed method design (Creswell & Clark, 2011; R. B. Johnson, Onwuegbuzie, & Turner, 2007; Tashakkori & Teddlie, 1998). The documentary research, semi-structured interviewing, and the survey were conducted sequentially with each method informing on the next. Figure 2 displays the overall interaction and timing of the methods.

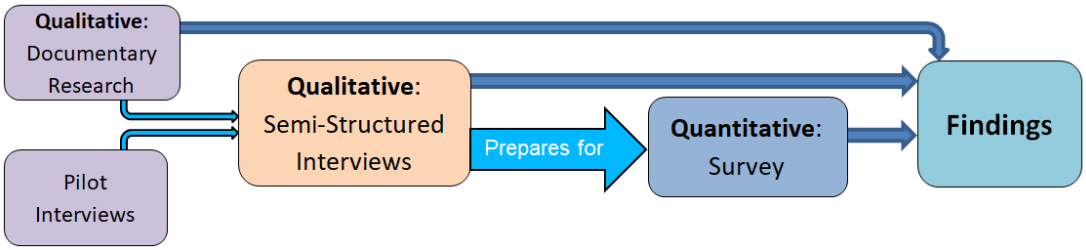


Figure 2: Mixed Method Exploratory Sequential Design with adaptation from Creswell & Clark (2011)

This use of mixed methods in a sequential order defined this study as a mixed method exploratory sequential design (Creswell & Clark, 2011, p. 71; Tashakkori & Teddlie, 1998). The rationale for using mixed methods was driven by the research questions. Different research questions were best answered with different methods. Mixed methods allows for both deductive and inductive research questions to be answered in a study where theory could both be generated and tested (R. B. Johnson & Onwuegbuzie, 2004). Through the development of rich descriptions, semi-structured interviews were utilized to explore military science instructors' beliefs about education. The survey identified how those beliefs varied across different military contexts. In addition mixed methods could supply a more complete explanation and potentially the weaknesses of qualitative research could be offset by the strengths of quantitative research and vice versa (Bryman, 2016, p. 642).

There are arguments against using mixed methods which typically center around the claim that qualitative and quantitative methods represent irreconcilable paradigms (Kuhn, 1970) that cannot be combined in the same study due to their ontological and epistemological underpinnings (Guba & Lincoln, 1994). But Johnson & Onwuegbuzie (2004) hold that the incommensurability of the two methods is overstated and that mixed methods research can be its own paradigm particularly if coupled with a dose of pragmatism. While there might be many ways to conduct a research study, if a study's research questions are of both a qualitative and quantitative nature, it makes sense to use a tailored mixed approach in answering them (R. B. Johnson & Onwuegbuzie, 2004). Furthermore, the tailored approach chosen of coupling interviews with a survey was fairly common. In a systematic review of 232 mixed methodologies studies, 57.3% of mixed methods designs consisted of qualitative interviews combined with a survey instrument (Bryman, 2006). This specific combination of methods was also common in the beliefs literature (Gow & Kember, 1993; Kember & Gow, 1994; K. Murray & Macdonald, 1997; Prosser & Trigwell, 1997; Trigwell & Prosser, 1996).

Lastly, the use of multiple methods allows the findings to be triangulated within the context of this study (Webb, Campbell, Schwartz, & Sechrest, 1966). Triangulation within in the social sciences is the combination of methods used in the study of the same phenomenon (Denzin, 2017, p. 291) in the efforts to "reduce the impact of potential biases that can exist in a single study" (Bowen, 2009, p. 28). This study used both semi-structured interviews and a survey to triangulate the beliefs about teaching and reported practices in a unique educational environment (Fielding, 2012). This benefit can be illustrated with an analogy from my US military experience. The US DoD provides triangulation for civilian and military use through their constellation of Global Positioning System (GPS) satellites, Figure 3, operated by the US Air Force. As the number of satellites used for triangulating a position increases, so does the reported accuracy of that position (Langley, 1999). The analogy would be more accurate if the triangulation was completed by other ranging and positioning methods such as star navigation, magnetic compasses and

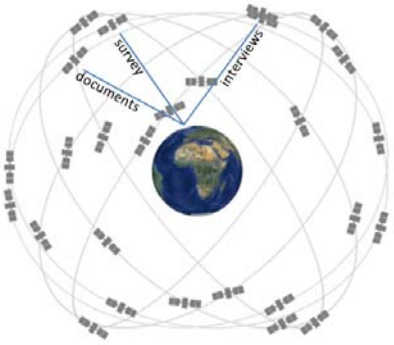


Figure 3: GPS satellites as an analogy for method triangulation (National Coordination Office for Space-Based Positioning, Navigation, 2017)

observers on a hilltop. This section provided a methodological overview of the study. The next section will discuss my background and positionality and how those might have impacted the study.

3.1.2 **Reflectivity: background and positionality**

Every researcher has a background which likely influences how they conduct their research. Avenier and Thomas (2015) argue that these factors potentially influence everything from what problems a researcher chooses to study, what methods they use to collect data, and how they choose to interpret data. While my formation as a researcher has been influenced by numerous background experiences, I will focus on the two most relevant aspects identified in reflection: those of my scientific background and my military officer background. Prior to beginning this research program, my academic education focused in chemistry and materials science. This foundation prepared me for answering research questions raised by the natural sciences (Royer, Kappe, Trogler, & Kummel, 2012). But my scientific background ran parallel to a military background. My education was funded by the US Air Force and I fulfilled an obligation of military service after each degree. I have been employed as a development engineer within the US military since 2005. My duties within the Air Force mainly involved researching, developing, testing, and evaluating weapon systems. The US Air Force also employed me as an instructor of chemistry. As an officer within the military, most of my engineering employment was in leadership roles within those organizations. Leadership within the military is multifaceted and the US Air Force defines leadership as "a delicate mix of art and science requiring people-oriented attributes, interpersonal communication, and an undeniable character that motivates, or wills, others to follow" (Department of the Air Force, 2017, p. 240). This combined background of science and military service shaped my research decisions. My science background translated into an attraction towards studying science education. But it also created an attraction to approaching social science research in a way that might be considered positivistic (Rowe & Oltmann, 2016). My leadership background translated into a desire to understand the people-oriented attributes (i.e. beliefs) and interpersonal communications styles (i.e. teaching practices) of other teacher/leaders. Reflectively I think my mixed background heavily influenced my research questions and my use of both quantitative and qualitative methods in studying science instructors in a military setting. My

background is also composed of ontological and epistemological assumptions and I believe I most identify with the critical realist perspective (Archer, Bhaskar, Collier, Lawson, & Norrie, 2013; Bhaskar, 1975). Pring's (2018, p. 17) states it well that critical realism is both a "belief in reality independent of my beliefs, hopes and feelings" coupled with the "constant doubt that I have ever quite captured it". This section described my background and how it might have influenced my research choices and assumptions. The next section articulates my reflections on my positionality while conducting my research.

Positionality was a concept I was mostly unaware of at the beginning of my research. Initially my thoughts of positionality were simplistic and only focused on how my "insider" status within the US military might affected the way I collected and analyzed data (Costley, Elliott, & Gibbs, 2010). Later reflection revealed that my insider status was both dynamic and nuanced. Aspects such as which branch of service I was with, whether a study participant wore a uniform or not, and even which academic subject the participant taught all affected my positionality. My positionality fluctuated constantly in relation to where I was and who I was with. I felt most like an insider within the US Air Force, my own branch of service, while most like an outsider within the US Navy. I also felt like more of an insider when working with instructors in uniform as opposed to civil servants. In addition to my insider status, another aspect of positionality that I noticed was the power between me and the interview participants (K. E. Smith, 2006). As mentioned in the literature review, the military is a hierarchal organization with power often defined through rank. With 23 years of military experience, I was accustomed to both being subjected to organizational power and holding that very power myself. But my awareness of power was tacit and rarely resulted in me reflecting on the subtle power imbalances always occurring (Staal & King, 2000). But I now approaching my military setting as both an officer and as a social scientist and I made deliberate choices to be more aware as to how these power imbalances might express themselves during an interview (Kvale, 2006). The most dramatic realizations in power were discovered when interviewing military department leaders holding the rank of colonels, see Table 2. In previous interaction with colonels, I have always been in a naturally subservient position, prepared to receive direction or orders. But as an interviewer, I needed to ask direct questions and then be critical of the responses in order to develop follow up questions. I am

aware that this new tension in power likely influenced my data collection and analysis, but I am not confident I have the analytical skill or experience to specifically identify how. It is possible that I deemed some responses as more trustworthy simply based on the organizational authority of the participant. This internal dialog on power began during my field work and I intentionally tried to address it as my data collection and analysis progressed. While the interviews with military colonels were the most pronounced cases of tension, I did notice different tensions between members of higher, equivalent, and lower military ranks. These tensions seemed to be mostly present when interacting with other military members. Interviews with civil servants, who do not wear uniforms, felt much more collegial. Even the interviews with civil servant department chairs, who held the same organizational authority as the military colonels, felt more collegial. In summary, positionality was no subtle matter in a military setting and I gained a new sensitivity to power relations in my community.

This section has presented the methodological overview of the research study and how my efforts to answer the research questions led to a mixed methods exploratory sequential design. I have also discussed how my personal background and positionality are framed within the study. The next section will move into more detail to discuss how the qualitative data composed of semi-structured interviews and document analysis were both generate and analyzed.

3.2 Qualitative data generation and analysis

The previous section outlined the overall methodological approach to the study. This section will examine how the qualitative data were both generated and analyzed. It begins with a discussion in section 3.2.1 of how access to the military institutions was gained and proceeds to how document analysis and semi-structured interviews data were generated (Smagorinsky, 2008). Lastly, section 3.2.3 discusses how the qualitative data were analyzed. As this study used an exploratory sequential design (Creswell & Clark, 2011, p. 71) the quantitative data collection were contingent on the analysis of the qualitative data. For this reason, the quantitative portions of data generation were delayed till after the discussion qualitative data analysis in section 3.3.

3.2.1 **Obtaining access**

During my research training program, I heard horror stories of the difficultly in gaining access to research site. This was backed up by warnings in the literature regarding the effort required to gain access to closed, non-public settings (Bryman, 2016, p. 425). I dismissed these warnings and assumed my US military insider status would provide easy access to a typically closed setting. My assumptions were based on an inadequate understanding of conducting research on human participants. Gaining access to personnel on US military instillations proved difficult yet insightful in the end. This section documents the processes for gaining access to a military setting and the unique peculiarities that presented themselves. This section might be lengthier than typical discussions of access but I feel that the experiences and observation gained during the process may provide evidence that supports certain findings in exploring science teaching in a military setting. These sections highlight how three different military organizations, operating under the same federal regulations, interpreted and applied those same requirements in different ways. These service specific approaches may contribute towards understanding the cultural differences between the services.

All US military organizations are governed by Part 219 of Title 32, Code of Federal Regulations: Protection of Human Subjects (Code of Federal Regulations, 2013) and the DoD Directive 3216.02: Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research (Secretary of Defense, 2018). These regulations ensure the protection of human subjects and are similar in nature to the Central University Research Ethics Committee (CUREC) process at the University of Oxford. I assumed that an ethical review of my study completed at one institution would be valid at the other institutions. This was an incorrect assumption and three separate reviews after my CUREC approval were required.

In additional to ethical review, access also required commander approval to be obtained at each institution and at various levels. Gaining commander approval was essential. In this respect being an insider did prove useful in obtaining access to supervisees. My personal knowledge of inner workings of these organizations and my familiarization with the customs and courtesies made maneuvering with commanders relatively painless. As discussed in section 2.1, military organizations

are hierarchal organizations, led by military leaders who are charged with accomplishing a mission. Members within a military organization are the primary resource by which leaders accomplish their mission. In their resource limited environment, leaders have to be convinced that any external request of their personnel's time, in this case access to the science instructors, is beneficial for their overall mission completion. For some organizations, permission to access the science instructors had to be obtained from commanders at several different levels within the organization. As mentioned, the process at each institution yielded different insights into their service specific culture. First, the specific process of gaining access at the US Air Force Academy will be discussed followed by a description of the process at the US military Academy and the US Naval Academy.

Gaining access to the United States Air Force Academy

As a member of the US Air Force, I began by seeking access at my home institution first. In general, the process was lengthy and involved. Beyond the approved CUREC review, my study required supplemental training, two more ethical assessments, and two commander approval steps. The US Air Force operates in accordance with Air Force Instruction 40-402, Protection of Human Subjects in Research (Secretary of the Air Force, 2014c) in addition to the federal and DoD instructions listed above. In accordance with these instructions, the US Air Force required any studies employing a survey first obtain a Survey Control Number in accordance with Air Force Instruction (AFI) 38-501 Air Force Survey Office Program (Secretary of the Air Force, 2014b). To obtain this assessment I had to first request permission of the Vice-Dean and of the departments to be studied. With their permission granted, my interview and survey questions were reviewed and deemed acceptable. Next, I had to gain an Institutional Permission Memorandum from the vice-superintendent at the US Air Force Academy. After gaining this approval I was finally able to submit my approved Oxford CUREC package to the USAFA Human Research Protection Officer for an administrative review. This review required changes to be submitted back to the CUREC office and required my academic supervisor to complete US DoD ethical training. Finally, I obtained all the approvals I needed to proceed. This process took approximately 9 months (August 2018 to April 2019). Much of this time was spent fulfilling a very detailed and technical process. With the Air Force, my findings

were that the regulations held power, or "rules ruled". I engaged in several disagreements over regulation interpretation. For example, one requirement stipulated that I have a "project officer" within the US Air Force Academy chemistry department on one particular application form. My argument that I qualified as such, as a former member of the department, currently on a department sponsored education program, in order to return to the department, was insufficient. My status didn't meet the narrowest interpretation of the instruction. After I capitulated on my lack of status, a current member of the department was used as a substitute. Their name was included on the form but they had no other involvement. The organization I was seeking approval from was content to allow all the requests to continue to originate from me, as long as a different name was on the form. In this case an intense adherence to the rules was followed, even if they added no apparent meaningful value.

Gaining access to the United States Naval Academy

My experiences with the US Naval Academy (USNA) were in sharp contrast to my experiences with the US Air Force Academy. In addition to the federal and DoD directives, the US Navy also adheres to SECNAVINST 3900.39E: Human Research Protection Program (Secretary of the Navy, 2018). The Human Research Protection Program (HRPP) Office at the US Naval Academy clearly laid out all of the access requirements (HRPP Office, n.d.). A single submission to their office of Oxford's ethical review (Reference# ED-CIA-19-060 [previously ED-CIA-18-242]), and validation of my training requirements was all that was necessary to begin the process. Approximately 3 weeks later I received approval to begin my study. Approval was given as the study was considered to be exempt of needing further review. Their exact language is important:

> *"The IRB Chair concurred with Oxford's determination. USNA is not engaged by a technical definition in the SECNAV Instruction. USNA can assist by providing instructors the ability to decide if they want to participate in your research or not. They can see that it was reviewed by USNA for ethical reasons. Feel free to contact the instructors."* (HRPP Office, personal communication, 18 December 2018)

Their interpretation of the same DoD regulations produced a markedly different response than that of the US Air Force Academy. Navy interpretation found my study exempt of needing more than

an administrative review. The decision to participate was handed to the lowest level possible, that of the individual instructors being studied. A concept of "decentralized authority" is developed in chapter 5 and my access observations support this finding from a different perspective.

Gaining Access to the United States Military Academy

Obtaining access to the final service academy was a third unique experience. Overall, the United States Military Academy (USMA) focused on minimizing paperwork while maximizing commander authority. The Human Subjects Research Protection Program (HRPP) office at USMA manages ethical review and in addition to federal and DoD instructions also operates in accordance with Army Regulation 70-25: Use of Volunteers as Subjects of Research (Secretary of the Army, 1990) in addition to USMA Regulation 70-25: Use of Volunteers as Subjects of Research. Their instructions allow ethical reviews accomplished by other DoD component, such as the US Air force, to be used in lieu of completing their own. In a conversation with the USMA HRPP office, they indicated that USAFA's review process was so stringent and thorough, that if the review was accomplished at USAFA, USMA would be happy to accept that review in lieu of their own (HRPP office, personal communication, 26 November 2018). The USMA ethics office was very pragmatic and in effect outsourced the review. But unlike the Navy, the Army wanted to ensure commander approval was obtained at all levels prior to giving authorization. Approval was accomplished in the form of a Command Support Letter from the dean's office. This letter detailed what support I would be provided by USMA. Additionally, support was first socialized informally between a supportive colonel involved in teacher development and the science department heads before being official requested through the Command Support Letter. In contrast to the Navy's approach of allowing the instructors to decide for themselves, the Army appeared to give priority to commander approval. This process supported a finding developed in Chapter 5 that Army commanders tended to exert influence and that Army members often sought to meet their commander's intent. Start to finish, obtaining access at USMA took approximately 3 months.

In conclusion, gaining access was a difficult process yet insightful to certain aspects of each organization. In addition to describing how access was obtained, this lengthy description was

provided as support for findings developed in later chapters. The observations noted in gaining access with the various service branches support findings that on what instructors believe about teaching and their reported practices. After access had been granted, it was possible to start collecting data. The next section describes how qualitative data were generated with document analysis and semi-structured interviews.

3.2.2 Qualitative data generation

For the qualitative portions of my study, both documentary analysis and semi-structured interviews were employed. Each method will be detailed separately below with attention to the rationale and specifics such as sampling and data collection. As described above in Figure 2, documentary analysis preceded and informed on the interviews and as such will be discussed prior to semi-structured interviews.

Document analysis

Document analysis was used as the "systematic procedure for reviewing or evaluating documents" (Bowen, 2009, p. 27). These next few paragraphs will describe my rationale for using documents, how I sampled and analyzed the document, and how the findings were used to shape the interview questions. I chose this method for the purpose of answering the second research question presented in section 2.3 on influences to beliefs and practices. It was selected as a method assist to guide development of the semi-structured interviews. I believe I was influenced to select this method based on cultural background within the US Air Force. From personal experience within the US Air Force, when I requested direction on how to perform some task I have often been met with the response "what does the AFI (Air Force Instruction) say?". The Air Force uses instructions, or rule books, to detail how almost all actions are to be performed. For example, AFI 36-2903 dictates everything related to dress and appearance down to details like hair length, acceptable fingernail paint colors, and even when a service member may use a mobile phone while in uniform. This instruction also prohibits putting hands in pockets except "to insert or remove an object" (Secretary of the Air Force, 2014a, p. 16). I believe my background in this culture led me to make assumptions that if instructors were to hold beliefs about education and practices, that these would be plainly documented

in some instruction manual. Evidence turned out to not support this assumption but documentary analysis did contribute to developing the interviews and answering the research question on influence (Goldstein & Reiboldt, 2004).

Document sampling and retrieval

My first step in conducting document analysis was to identify which documents to sample. I sought to identify documents that would best answer my research questions by focusing on their content and authorship. Documents related to teaching or activities in the classroom or documents authored by or set as required reading by an instructor's chain of command were identified for analysis. With my criteria established I began the process of retrieving documents. I began first by searching each academy's website. I focused on searching in the academic dean's webpages and in any areas that seemed related to pedagogic practices development published online. The exact number of documents accessed was unknown and most documents were quickly eliminated in accordance with the criteria above. These criteria yielded handbooks, guidance's, and manuals and the most relevant documents are listed below in Table 6.

Table 6: Sample Documents identified during document sampling that met selection criteria

School	Document Title	Author/level
USAFA	Faculty Handbook (2013)	Dean of Faculty
	Faculty Handbook (2019)	Dean of Faculty
	Curriculum Handbook	Dean of Faculty
USMA	Dean's AY19 Annual Guidance	Dean of Faculty
	Dean's AY18 Annual Guidance	Dean of Faculty
	Educating Army Leaders	Dean of Faculty
	Faculty Manual (2014)	Dean of Faculty
USNA	Faculty Handbook (2015)	Dean of Faculty
	Dean's Annual Letter (2019)	Dean of Faculty
	Faculty Performance Expectations	Dean of Faculty

The documents in Table 6 were collected in electronic form and were in existence prior to this study. Scott (1990, p. 14) puts forward a useful scheme of describing types of documents and has been employed in this study. Scott's framework classifies documents based on their authorship and accessibility. All documents studied fall have *official-state* authorship and their access is *open-*

published. The documents were mostly teaching faculty handbooks, annual guidance from the dean, or performance expectations. This initial search proved to be an efficient process and data collection occurred quiet quickly. But after initial efforts I began to encounter hurdles with documentary analysis.

In describing the teachers "chain of command" there are several levels of command. Instructors have supervisors, who in turn are supervised by the department leaders, who are supervised by the deans. I quickly found documents generated by the deans and I assumed that there were similar documents generated by the department leaders or supervisors. Efforts at collecting these documents was additionally hindered by lack of any access prior to gaining access to the interview participants. As mentioned above, access had an ethical component and commander support element. While the documents did not need ethical review to collect, the human research offices discouraged me from requesting anything from the departments prior to gaining ethical approval for the interviews and survey. Only after I gained access did I learn that the documents at the department and supervisor level did not exist.

Document quality and shaping of interview questions

With documents in hand, I began to assess their quality with Scott's (1990, p. 19) four criteria of *authenticity*, *credibility*, *representativeness*, and *meaning*. As these were official state documents obtained from official websites there were no issues of authenticity or credibility. Documents were deemed as representative of the institution's desired qualities in teachers. It was not assumed that teacher's beliefs or actual practices aligned with these institutional directions. Lastly, there were no difficulties in understanding the meaning of the documents. Most documents, as handbooks, expressed clear, understandable direction when relating institutional values, promotion criteria, or other policies. Also, as they described a military context, a certain amount of military awareness (Scott, 1990, p. 30) was useful in interpreting their meaning. My personal background in the US Air Force provided this awareness for most situations, such as the use of military terms or jargon. Yet even with my background, I was confused by some descriptions in the US Army and US Navy. One example was a pedagogical practice in the army called the "Thayer Method". I was uninformed of this

method until I followed up about it during field work with the army. After assessment for quality, the documents were analyzed. The next section discusses how this analysis was conducted and helped shaped the interview questions.

As part of the sequential design, documentary analysis was designed to assist in shaping the interview questions. To accomplish this, I first analyzed the documents. In truthful retrospection, my efforts at this first analysis of qualitative data were very rudimentary. I simply tried to answer the specific research question "what teaching practices do the guiding documents support?" I approached analysis too narrowly focused and looked only for specific instructional methods mentioned. After gaining more experience analyzing interview data, a better approach was employed asking how the entirety of the document would create a culture supportive to certain practices. But with my initial narrow view I only found one document that described teaching practices in the classroom at any length (United States Air Force Academy, 2013). This document endorsed a "learning-focused practice" and spent several pages describing that paradigm and provided examples of how to use it in the classroom. These learner-focused views corresponded to similar views I had been encountering in teacher beliefs literature (Barr & Tagg, 1995; Huba & Freed, 2000; Kember, 1997; Mazur, 2009; Michael, 2006). This influenced the beliefs portion of my interview questions, see Appendix A, to focus on beliefs along the student teacher spectrum, (Ho et al., 2001; Luft & Roehrig, 2007). Several documents listed in Table 6 above mentioned promotion criteria involving "teaching excellence". I translated this into interview questions further refined in piloting seeking to connect career motivations to teaching practices. Lastly, as described above, documents at the department level were unable to be located or did not exist. As there were no descriptions of what initial teacher training included, I added questions seeking this information to the interview schedule, see Appendix A: Interview schedules questions 6-8. As noted above, while my initial documentary analysis did have some hurdles, it did supply evidence of research question as well as influence the interview questions. A second round of analysis was performed after I had collected and analyzed my interview data. With a better understanding of qualitative analysis, the three different military contexts and the instructors I was able to draw more conclusions from it.

Semi-structured interviews

Semi-structured interviews (Brinkmann & Kvale, 2015) represented the bulk of the qualitative data collected in the study. This section discusses the justification for using semi-structured interviews and how they were carried out. This section discusses how the interview questions were developed and piloted. It also discusses how the participants were sampled and accessed, and how the data were collected. Reflection on how my plans changed during the planning phase and data collection will be also interspersed throughout the section. My rationale for using semi-structured interviews was simple, the method was found to be the best way of answering five of the six specific research questions presented in section 2.3. This estimation was based on their prior use in beliefs literature and the exploratory nature of the study. While there might be several ways to investigate beliefs and practices of instructors, interviews were the most reported method (Dall'Alba, 1991, 1994; Gow, Kember, & Sivan, 1992; Kember & Kwan, 2000; Prosser, Trigwell, & Taylor, 1994; Samuelowicz & Bain, 1992, 2001; Veal, 2004). As this study was exploratory, semi-structured interviews also provided the flexibility to explore beliefs or ideas that presented themselves during the interviews. With the method chosen, I will next discuss how interview questions were developed and piloted.

Interview question development and piloting

This section will discuss how I developed my interview questions. My interview questions were designed to bring forth beliefs and reported practices useful in answering my research questions. The questions were guided by literature, document analysis, piloting and the actual fieldwork. Different research questions influenced the development of the various sections of the interview schedule. The interview schedule, Appendix A: Interview schedules, consisted of three major sections. It began with a background section, moved to a section on beliefs and practices, and concluded with questions about influences. The development of each section is described below.

Interview schedule section development

The background section included many of what Brinkmann and Kvale (2015, p. 160) termed as introductory questions. This section functioned as an ice-breaker and put the respondent more at

ease. I used this time to generally ask about the background and experience of the instructors as well as the events leading up to them becoming an instructor at a US service academy. The demographic questions were adapted from other studies investigating teacher beliefs (Coffey & Gibbs, 2002; Norton et al., 2005). I also included questions about teacher training programs as previously discussed above in the documentary analysis section. In preparation for the interviews with department leaders, I created a dossier on each individual using publicly available biographical information and military service records (Brinkmann & Kvale, 2015, p. 171; K. Goldstein, 2002).

In seeking to answer the research questions exploring teacher beliefs, existing literature on teacher beliefs (Ho et al., 2001; Johnston, 1996; Luft & Roehrig, 2007) was extensively utilized. Originally the beliefs questions comprised the same eight questions from Luft and Roehrig's (2007) Teacher Belief Interview. These questions were designed to probe science instructor's beliefs about teaching and learning but in the context of secondary school science. A second rationale for using Luft and Roehrig's (2007) Teacher Belief Interview was that they included a detailed plan for conducting thematic analysis on the answers. I had envisioned using the same framework proposed by Luft and Roehrig (2007) to analyze my data. This framework ended up not being utilized as will be discussed below in the analysis section. During piloting, these questions were felt insufficient in fully exploring beliefs about teaching and two more questions of a more general nature from Ho et al. (2001) were added.

The last phase of the interview contained a series of questions designed at answering questions about the military context's influence on teaching. While specific questions about exploring beliefs were contained in the literature, I only found questions of a general nature seeking connecting context to teaching (Lindblom-Ylänne, Trigwell, Nevgi, & Ashwin, 2006; Neumann, 2001; Neumann, Parry, & Becher, 2002). Some initial questions were generated with the researcher's insider knowledge of the military and additional questions on topics such as power and career were generated during pilot interviews. Due to a different research question pertaining to the department heads, as displayed in section 2.3, a slightly different set of interview questions were developed for the department heads. Instead of exploring how the military context had shaped them, I explored how they were trying to shape their instructors. But in general, both sets of interview questions contained

three topics covering demographics, teacher beliefs, and questions seeking to understand how the military's context influence had influenced these beliefs.

Pilot interviews

In addition to literature and documentary analysis, the interview schedule was influenced by pilot interviews. A total of three pilot interviews were conducted. These were conducted locally with three US Air Force officers that were previously instructors at the US Air Force Academy. These individuals were selected for their similarity to the intended population and their convenient access (Patton, 1990). These participants were University of Oxford students and could be approved as test subjects by the CUREC process describe in section 3.2.1. They differed from the target group in that they were not current instructors and that they instructed non-science disciplines such as engineering, philosophy, and behavioral science. They also represented only one of the three services, the US Air Force. But the pilot interviews were still very beneficial to shaping the interview schedule as will be described.

The piloting produced two new interview questions (Q23 and Q24 of Appendix A: Interview schedules). The first question was on the nature of active power management in the classroom. One teacher reported that they were particularly sensitive to how their power, in the form of superior rank over their students, might change the nature of their students' participation in the instructor's philosophy class. They intentionally had students forego certain customs and courtesies expected in the military classroom. The instructors also actively assumed a physically similar posture to the students by sitting in and among them rather than standing at the head of the classroom. They mentioned that they did this to actively bring about a more egalitarian nature in the student-teacher relationship during instruction. They believed this made for a better student learning experience and that that these efforts would allow the ideas of both instructor and students to be evaluated on an equal plane. This example influenced me to explore how others might be aware of power in the classroom or seek to actively manage it. A second pilot participant also discussed how their supervisor would assess their instruction techniques. The instructor had concerns that if they didn't teach the particular way their supervisor wanted that it could have negative implications on their military career

advancement. This finding prompted an additional question investigating the connections between career progression and teaching styles.

In addition to trialing my questions, pilot interviews were also useful in addressing my relative inexperience as an interviewer. During my pilot interviews, I realized that many of the belief and practices questions were of the nature "how do you conduct some act of teaching" One respondent seemed to be answering these questions with an idealized version of what they thought they should do. Without prompting, they gave an illustration of a practice that seemed to contradict their stated belief. To address this apparent disconnect I realized the value of using probing questions like "can you give an example of that?" to bridge the gap between belief and reported practice (Brinkmann & Kvale, 2015). As my interviews were semi-structured, opened-ended interview questions could be followed up with clarification prompts (Bryman, 2016, p. 468).

Lastly, one interview question was added during the first few interviews while conducting fieldwork. At the end of an interview with a department head, I asked if he had any last thoughts. He response started with "You know what I would want to know if I was studying this group?" and concluded with an aspect of understanding how other services were teaching a certain topic. After the interview, I reflected on the intersection of the exploratory nature of my study and my dual objectives to my DPhil program. Not only do I plan to make a meaningful and substantial contribution to knowledge, but I also seek to provide meaningful contribution back to the departments that have granted me access to study them. When considering the exploratory nature of my study I added the following question to the end of the interviews: "If you were studying science instructors across the military service academies, what would you want to know?" It was interesting to find out what instructors and department heads actually wanted to know about each other. Answers to this question ranged from the very specific "how are we doing on X" to the more philosophical "how much physics do our officers really need to know?" After the interview schedule was developed and piloted, it was time to sample an access the participants.

Participant sampling and access

This section describes how I sampled interview participants who would provide the most relevant data in answering the research questions (Bryman, 2016, p. 408). The research questions presented in section 2.3 focused on exploring the beliefs and reported practices of teachers and authority figures across different military contexts. Correspondingly, I purposeful sampled (Suri, 2011) a variety of instructors and those in authority, across each institution. Both groups will be discussed below.

When sampling instructors, I had the choice of military and civil servant instructors (Keller, Lim, Harrington, O'Neill, & Haddad, 2013). Military instructors were mainly of two types. Either they were on their first teaching assignment with a MS degree or on their second teaching assignment with a PhD. Civil servant instructors were more similar to the type of professor found in a non-military school. These instructors typically held PhDs, had more teaching experience than their military counterparts, and were tenured professors.

My original plan focused only on studying the military instructors on their first teaching assignment. This sampling corresponded to a previously used narrow research question only interested in active-duty military instructors who could be considered deviant to the traditional higher education setting (Patton, 1990). When I later opened up my research questions to include all instructors in these military settings, my sampling correspondingly widened to include both the military and civil servants. This wider approach yielding a greater variety of responses and was perhaps more representative of the military academic context (Creswell & Clark, 2011). While all instructors teach the "core" courses, I did choose to focus on instructors who were more centrally involved in teaching the core courses. As described in section 2.1.3 of the literature review, core courses at these military institutions are the required classes for all students, including chemistry, physics, and biology. While the core courses were not specifically mentioned in the research questions, it was my assumption that instructors teaching this core would be possibly more influence by their surroundings. This assumption was also based on my personal experience within the military and the understanding that the non-core, upper division major specific classes allowed instructors

much more freedom, while the core classes might dictate certain practices on the instructors. Sampling of the core instructors and additionally core course "directors" also was an influenced by documentary analysis. As mentioned above, I thought certain documents existed within the department that might dictate teaching practices. These documents did not exist, but during the unfruitful search to locate them I learned that the role of these core course directors seemed to fill that "this is how we do things" function. In the end, I sampled at least one military instructor and at least one civil servant from each of the seven departments that I visited.

Gaining access to the participants was relatively simple after the ethical reviews were completed. As noted in the access section above in section 3.2.1, gaining access required both ethical review as well as commander approval. After I had gained commander approval, the departments opened their doors to me and were very responsive to all requests. I identified specific candidates to interview from online faculty rosters and through email requests to department staff. If I could not obtain a roster online, I requested groups of names of military instructors in their first assignment, the names of course directors, and a list of names of civilian instructors. From these lists I selected a name at random and contacted them via email for participation. During fieldwork, some participants became unavailable and I had to identify replacements from my lists on the spot. I was continually surprised at the instructors' willingness to participate and only 1 subject of more than 25 declined to participate. Since I was able to access all 7 science departments at these three schools, I chose to spread the interviews as equally as I could prioritizing breadth of exposure over depth in one department (Brinkmann & Kvale, 2015, p. 140; Sandelowski, 1995). Typically, 3 (but up to 5) interviews were conducted in each department containing 20-50 teaching staff.

In addition to the planned interviews, during my fieldwork I also identified four "targets of opportunity"[2] who might have been particularly helpful in answer the research question on how beliefs and practices varied between cultures. These took the form of instructors who had teaching experiences in two different US military service academies. I had not originally planned on

[2] "A target identified too late, or not selected for action in time, to be included in deliberate targeting that, when detected or located, meets criteria specific to achieving objectives and is processed using dynamic targeting" (Office of the Chairman of the Joint Chiefs of Staff, 2019, p. 212)

interviewing these participants but saw their experience with two different teaching environments within the US military as a possible opportunity to gain unique insight comparing contexts. In a way they acted as key informants (L. Cohen, Manion, & Morrison, 2011a, p. 180) and were able to provide insightful statements like "well in the army they do it like this, but back in the Air Force we did it like that". These contrasted reflections of practices were useful in prompting areas of focus when analyzing the different approaches to teaching in different services. In addition to the instructors, I also sampled the lead of each department, known as the head or chair. They were sampled in order to answer the research questions on influences of beliefs and practices. It is important to note that in addition to the leadership and administrative role, all department heads and chairs still taught in the classroom. As there was only one individual in this position per department, selection was by default. I had some concerns about participation rate considering the singular positions, but fortunately all department heads or chairs agreed to participate.

Before moving to data collection, I must acknowledge a noteworthy deviation from my original plan in respect to interview sampling. I had originally planned to interview the academic deans at each school but I was not given access to them. Without access, I had to eliminate a research question investigating them directly. In a way, planning social science and military operations are similar. With military planners, "no plan of operations extends with any certainty beyond the first contact with the main hostile force" as quoted by Field Marshal Helmuth Karl Bernhard Graf von Moltke in Hughes (1995, p. 95). The deans were content to allow me to conduct my research in their organizations but were unwilling to participate personally. This was not an unexpected surprise. These deans qualify as elites and hold the rank of one-star generals or the civil servant equivalent. It is to be assumed there are many requests of their time and my study was simply not a high enough priority. With access to the deans being denied, I correspondingly eliminated the research question involving them. But the elimination of that specific research question did not eliminate the indirect participation of the deans. The dean's views were accessed through the documents mentioned above that mainly originated from their office. This proved an alternative method of analyzing their beliefs and the context they intend to shape. With participants sampled and accessed it was time to collect my interview data.

Data collection

I conducted the interviews during a fieldwork trip in April 2019. The trip lasted about 2 weeks in two geographically separated locations within the US. I began the first week on the US east coast where US Army and US Navy schools were located. I began my trip with institutions that I was less familiar with and concluded at my former institution. This order was an insightful recommendation by my academic supervisors and by the time I arrived at my institution I felt able to view afresh with insights from the Army and Navy. I spent the first 2.5 days conducting interviews with the Army, then drove 4 hours to spend 2 days conducting interviews with the Navy. After the first week I flew to the center of the US to the Air Force school to conduct interviews. With a couple extra days at this location these interviews were stretched over 4.5 days.

My site visits began with gaining physical access to the schools. The schools maintain armed physical security and are closed to the general public, but my active-duty military officer status permitted easy gate access. I then checked in with each science department to remind them of my visit and confirm my schedule. As discussed above, not every interview was scheduled prior to arrival and after arrival some participants became unavailable. I was surprised by the effort of both the departments and the individuals in assisting with finding replacements. One participant's spouse had a child a few days before I arrived at their department. I had to stop them from making arrangements to come in from paternity leave to complete the interview. They said they were "happy" to do it and considered it "important". I am unsure if their use of "important" was in reference to them considering the study important, or maybe a sense of important duty to the department, or perhaps just even an "important" break from the general stresses of the first few days of parenting a newborn.

The interviews were conducted at or near the participant's work space in a quiet place of their choosing. Interviews began with an explanation of the study information sheet followed by the signing a consent form. I recorded all interviews with a digital audio recorder as all participants agreed to its use. A total of 25 interviews were conducted averaging 44 minutes each. The shortest interview was 26 minutes and the longest 111 minutes. While the pilot interviews did help, my first few interviews demonstrated my still lack of experience at interviewing and use of my interview

question sheet. I had anticipated that my interviews would take a much more linear progression in line with my interview questions. In actuality, participants began volunteering answers to questions all over my list of interview question. I had a difficult time keeping track of which questions were being answered and I often felt like I was asking questions which had been given answers 10 minutes ago. After the first few interviews I was better able to manage my attention to their answers with my attention to my questions. Every effort was made to avoid writing notes during the actual interview (Brinkmann & Kvale, 2015, p. 205) as to not distracting the interviewees. At the end of interviews, the participants were thanked for their time. I also learned quickly to keep the recorder close at hand at the end of the interviews. After we concluded my questions, the participants often wished to continue the discussion. With their consent, I simply restarted the recorder to capture these parting thoughts.

After the conclusion of the interview, I paused to make field notes concerning any significant details or general impressions of how the interview proceeded. One example field note was about an interview that started normally but ended up rather rushed at the end. The interviewee had several doughnuts at the start of the interview and then had to excuse themselves to get a drink of water midway through. After the midway point they were eager to speed the pace of questions and seemed distracted. I recorded this change in behavior in my notes after the interview. Upon later analysis and listening to the interview data I looked for possible reasons for offence on my part, but could not locate any. There could have been many reasons for the change in behavior, perhaps an upcoming appointment or a swing in blood sugar levels.

After interviews I also took the opportunity to note any preliminary themes to explore later (Bryman, 2016, p. 472). For example, certain phrases such as “commander’s intent” were recorded in Army field notes and “captain at sea” in regards to teaching were recorded in field notes from the Navy. These two phrases ended up becoming concepts regarding how different institutions approached aspects of freedom of teaching methods and will be discussed in findings chapter 5.

I spent my time between interviews in the departments. I collected a few photographs of the teaching space to include in my field notes about the context. I also utilized the opportunity to socialize around the departments in an effort to meet as many instructors as possible. I did this in the

hopes of improving survey participation in a later phase of the study. In the evenings during fieldwork, interview audio data were backed up to a secure secondary hard drive in accordance with Oxford's data handling guidelines (Research Data Working Group, 2020). I sent thank you notes via email to all participants. At the end of my field work, I prepared a trip summary to capture the summation of my first thoughts of the trip and some initial data analysis.

3.2.3 **Qualitative data analysis**

The previous section discussed how I generated the qualitative data. In this section, I will seek to provide sufficient detail (Smagorinsky, 2008) as to how I analyzed that qualitative data to produce findings useful in answering the research questions. This section is a discussion of how qualitative analysis was a journey that began with a deductive approach but ended with an inductive approach. The various components of this journey will be described in phases and include data processing, difficulties with employing an existing framework to my study, a shift to grounded theory and the final efforts at making meaning. Table 7 was developed below to depict a general outline of the analysis process with influence from various sources (Braun & Clarke, 2006; Luft & Roehrig, 2007; Strauss, 1987).

Table 7: Qualitative data analysis by phase with analytical process and objectives

Phase	**Analytical Processes**	**Strategic Objective**
Phase 1: Data Processing	Transcription 1st listen through Recording demographic data	Data Management ^ | | v Descriptive Accounts ^ | | v Explanatory Accounts
Phase 2: Discarding of existing frameworks	Marking of question response location Coding answers with Luft (2007) and the associated difficulties	
Phase 3: Efforts at Grounded Theory	Open Coding Initial Grouping of Codes	
Phase 4: From GT to making explanation	Minute coding Memoing Categorization of codes Analysis across cases	

Each phase is contained in Table 7 as well as the analytical activities and the strategic object of that phase. Each phase is more through discussed below. This representation in table form makes

the process appear more structured and orderly than it really occurred. In actuality this chart was developed by retrospection of the process that had occurred.

Phase 1: data processing

Interview audio files were first prepared for analysis by transcribing them. To save time, I utilized an automated transcription service to perform the bulk of the transcript and followed up with a manual check after. Due to general concerns about privacy, I chose a transcription service with a clear and transparent privacy policy that adhered to all ethical guidelines (Central University Research Ethics Committee, 2019). The audio data were clear with minimal background noise and all participants spoke English as a first language. This resulted in a surprisingly accurate automatic transcription requiring only a few corrections per paragraph. The algorithm could identify different speakers, insert punctuation, and even capitalize proper nouns. Most errors occurred with the transcription of acronyms or numbers. I had only planned on my initial pass through the data to serve as a check of transcription, but the transcription accuracy was so high that it afforded time to listen to the content of the interviews as well.

Listening to the interviews for the first time was an unfamiliar experience. I had never listened to recordings of my own conversations. Without the need to contribute to the conversation, I was able to focus almost all my attention on simply listening. I noted my inexperience at interviewing by my lack of what seemed like presence in the moment at times. There were several instances during the interviews where I asked the wrong follow up question or derailed what could have been insightful ideas that the interviewees were developing. Viewing transcribed text was also a useful experience. I became familiar with its broken and incomplete nature. Connecting the audio to the transcribed text was also useful in increasing the context of the written text. The addition of tone and speed filled gaps where the mean of the text alone might have been ambiguous. In later transcript readings, I could usually recall speaker inflections just as one might internalize a melody when reading song lyrics. I was cognizant that I might be introducing meaning error through relying on my memory. To assess this, I played back the original audio at several instances to check for introduction of error. Fortunately, I found no instances of adding inflection where none existed. These checked

transcripts were then imported into a qualitative data analysis software program, NVivo 12. Each interview file was associated with a set of attributes based on the demographics of each interviewee. These attributes included such things as military or civil servant status, gender, academic subject, service branch and teaching experience. With my interview data initially processed, I began the next phase of analysis and focused more specifically on the analysis of the content.

Phase 2: discarding existing frameworks

In the previous phase I had listening through the data without trying to analyze it (Bryman, 2016, p. 581) but analysis had been subconsciously occurring throughout the data collection process. At this point I began a concerted effort to deductively use Luft and Roehrig's (2007) framework that had helped shape the interview questions. After the first listen through my interviews, I began to tag the locations of each interview question response. I now began to analyze the content of the responses. Almost immediately I began to notice a general disconnect between my planned framework and the nature of the instructor's responses. My expectations had been set by a common theme in teacher's beliefs about teaching centered on teacher-focused versus student-focused beliefs (Handelsman et al., 2004; National Research Council, 2012; Nichols & Miller, 1994; Reiser & Dempsey, 2012; Wieman, 2014). As mentioned in the interview question development, I had structured my specific interview questions on studies (Ho et al., 2001; Luft & Roehrig, 2007) investigating beliefs along this spectrum. But the instructor responses weren't matching well to this view. Although I couldn't articulate it, I began noting at this point was that something about teaching science in a military context was about something different.

In their description of the Teacher Beliefs Interview (TBI), Luft and Roehrig (2007) presented a rubric for analyzing responses to the interview questions. Since I had used their questions, I also planned on using their framework to identify where my instructors fell in the spectrum of teacher-focused versus student-focused orientations. While some of my data fitted into one of the five orientations described by Luft and Roehrig (2007), I soon began to encountered problems with responses I could easily place into one of the categories. Here is an example from the data. An item

from the TBI asked "How do you decide when to move on to a new topic in your class?" The supplied criterion for evaluating the answer is provided below in Figure 4.

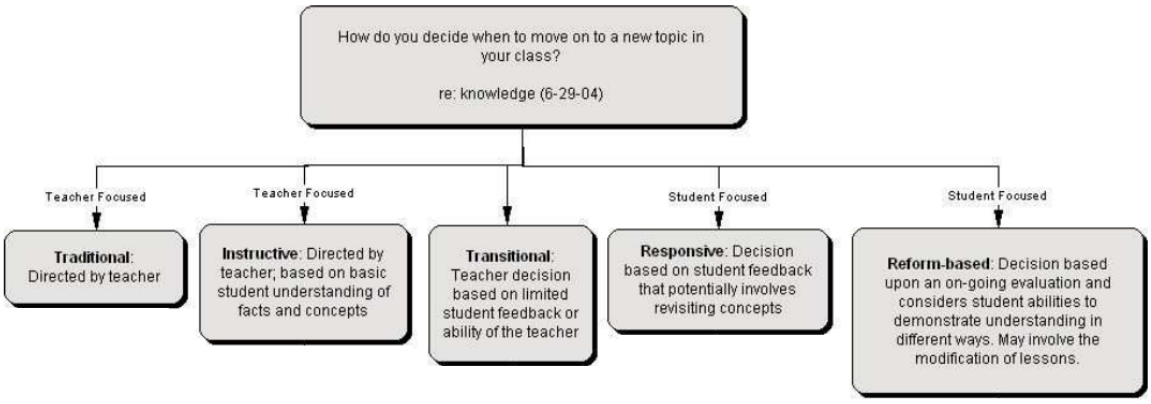


Figure 4: Luft and Roehrig (2007, pg. 61) criteria for evaluating teacher beliefs. Instructor responses didn't fit and this framework was eventually discarded.

Sample answers for the teacher-focused orientations were teacher directed, such as "when I have covered the material". Sample answers for the student focused responses were based on evaluation of the students' progress or "on going evaluation of student feedback". I was confused when I tried code an instructor's response of "usually when I am directed to by the course director[3]." The instructor's teaching pace was dependent neither on what they had covered or how the students were progressing but rather on a different external factor outside the classroom. The analysis framework I had begun with described how to differentiate between teachers sensitive to their students' learning and teachers focused on their own knowledge. But what if teachers seemed very sensitive to their students, as was evident in other parts of the data, yet were being directed to teach a certain way? A majority of the teachers interviewed were given a course syllabus and told to "execute" it in a certain manner. Topics to be covered in class were assigned exact dates and instructors taught those topics in time for graded events common between instructors. Furthermore, creating the graded events was often beyond most instructors' control. Even if a teacher described a nuanced way of interacting with students to increase student engagement, I found no category in the TBI spectrum for describing this type of answer (Luft & Roehrig, 2007). Choosing categories felt

[3] Course directors could be more actually described as course administrators. At two institutions they controlled everything about the course from the teaching topics, schedule, and even created all the graded events.

like describing teachers in a way that wasn't answering the research questions. At this point I made the decision to take what I had learned from this deductive approach and to try something different. In retrospect, it was useful in helping me start to think about my data but maybe not the ideal choice for an exploratory study.

Phase 3: efforts at ground theory analysis

After discarding my previous analysis process, I turned to the qualitative methods textbooks (Bryman, 2016; Flick, 2009) to identify a more inductive process to answer my research questions. Bryman (Bryman, 2016, p. 581) recommended a general inductive coding practice as a starting point for qualitative data analysis. He also described coding as giving labels to portions of data that might have theoretical significance or that could be salient to the social world being examined (Bryman, 2016, p. 573). I began to code my data but many codes simply resembled the marking of occurrences, similar to previously marking of specific interview question locations. For example, instructors at one service academy would mention a local pedagogical style they termed the "Thayer method," which I dutifully coded at every occurrence. This descriptive code contained no real analysis and could have likely been coded with a simple text search. But some codes could be considered concepts and contained a level of explanation or analysis. One example was what I coded as "peer support" where I noted instances where instructors relied on each other for their teaching with either resources or advice. This idea presented strongly in both inexperienced instructors accounts and with experienced instructors. Senior instructors made themselves available to help junior instructors. There appeared to be a strong element of teamwork among the instructors of a department. I can also say reflectively at this point that my military background possibly began to reveal itself in my coding. Peer support could be considered an essential aspect of teamwork a skill vital to success in the military and something I was possibly sensitive to. I continued this way through my data until approximately 50 codes had been generated, a majority of them descriptive in nature.

While I had begun generating codes, I felt like my codes lacked a coherence structure and were contributing little towards answering my research questions. I returned again to the literature to seek more inspiration on how to fully analyze my data(Bryman, 2016, p. 569). I decided that

Grounded Theory (Glaser & Strauss, 1967) would be the best approach to answering my research questions. I read up on the basics of Grounded Theory (Strauss, 1987; Strauss & Corbin, 1990) and returned to my data seeking to develop *concepts*, or the conceptual labels to apply to discrete phenomena (Strauss & Corbin, 1990, p. 61). I accomplished this through *open coding* strategies such as asking lots of questions about my data and coding portions of it very minutely (Strauss, 1987, p. 31). I moved much more slowly through select portions of text that seemed to be more theoretically significant. I spent as much time on a single paragraph as I had spent on several pages of text during my previous analysis. I interrogated every word in efforts to identify and code concepts that revealed conditions, interactions among actors, strategies and tactics, or consequences (Strauss, 1987). I especially looked for codes that might pertain to my research questions. After working through several small pieces of data and generating a number of new codes, I felt much more confident to return to the bulk of it. On my next pass through my data concepts were much easier to identify. Here is one example of how I developed one concept from the text. It came out of a passage of text where an instructor and I were discussing the possible benefits with the exchange of teaching ideas between the various service academies. The instructor mentioned that he thought it would be more valuable for others to come watch what his department was doing rather than the other way around.

Instructor: *I have gone and see them [the other service academies] and they do all right, but I think we do better.*

Interviewer: *What is it that "we're doing better?"*

Instructor: *I think we put out a better product. I think our students know their chemistry better. – US Navy, civil-servant instructor*

What did the instructor mean by "product"? Were they viewing their students as deliverables from a factory? What made a good product in their eyes? That they "know their chemistry better"? I felt this discussion revealed a belief about teaching held by the instructor and this concept was provisionally coded as "goals of teaching". Other teachers had other aspirations for their students and they were given other codes. As the number of concepts began to increase so did the length of my list of concept codes. My existing codes were organized alphabetically and it soon became cumbersome to scroll through and select the appropriate code. To ease the process, I started to organize codes into nested groups of similar concepts, in this case various the goals of teaching were grouped together. I

had naturally begun to develop a class of concepts called *categories* (Strauss & Corbin, 1990, p. 61). These were groups of related concepts under the umbrella of a more abstract concept. One early tentative category was the concept of the "whole person" that teachers were trying to develop in their students. This category fell under the higher category of teacher-student interactions and it contained sub-codes of different ways teachers were trying to develop the whole nature of their students. Example sub-codes included character development, mentorship, and in vivo codes like "life hacks" (non-academic skills useful for day to day living). Figure 5 graphically illustrates this arrangement and also shows how the sub concepts such as character development were *properties* of this category and that each property could vary along a *dimension* (represented by the blue arrowed line (Corbin & Strauss, 2008, p. 159).

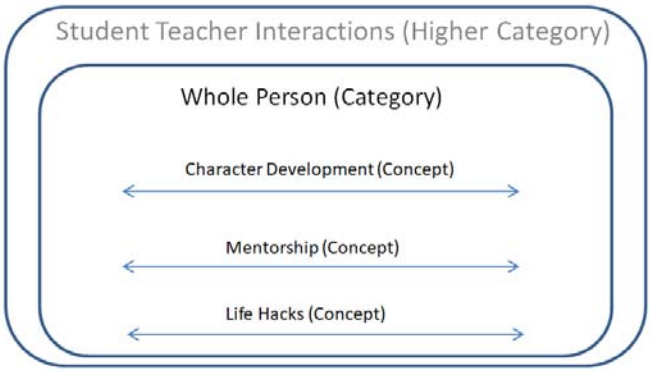


Figure 5: Categories as groups of concepts

Other provisional categories that were developed included: teacher development, teaching techniques, and managing authority. During this analysis I also began the process of writing memos about my analysis and findings (Corbin & Strauss, 2008, p. 117). These were helpful in developing ideas about my categories and raising questions that I would have to return to the data to answer. On this second pass through the data, I had created approximately 125 concepts grouped into several categories. These categories and their sub concepts were still considered provisional at this point and any alignment with the research questions was coincidental.

Phase 4: towards building theory

After the generation of my initial categories, I returned to grounded theory (Corbin & Strauss, 2008) to learn new ways to continue analyzing my data. The concept of *axial* coding was described

as relating different concepts to each other (Corbin & Strauss, 2008, p. 198). I began by looking for connections across my categories, especially in consideration of my research questions. Strauss and Corbin (Strauss & Corbin, 1990, p. 96) recommend looking for the interplay between the conditions or context of events and their consequences. In continuing to work with my data, I began to connect concepts in new ways. While there was no perfect way of organizing my data, certain arrangements seemed to better explain things. Early organizations of my concepts and categories lacked connections.

Here is an example of how a practice later became linked to an instructor belief. One concept that kept recurring was of a "captive attendance". I used it to document every time an instructor mentioned how class attendance was mandatory, they were actually a captive audience. I used this as a description on the context they were a part of. What I initially did not do was connect it to the next often occurring concept of "generate interest in science" where teachers described various strategies that they used to motivate students to apply themselves to their topic. Some instructors felt obligated to make their classes more engaging simply because their students had no choice on attending their class. In this instance, the early organization of my research question might have been influenced by the disconnected nature of my research questions. I had separate questions for understanding context, beliefs, practices, and influences where the reality appeared that all of these were playing out simultaneously. By engaging in axial coding, I was able to relate concepts back together again in new ways such as this. With this additional experience in analyzing qualitative data with Grounded Theory, I took the opportunity to return to the documents I had previously analyzed and examined them again.

I approached these texts now with a number of concepts already developed. I was much more sensitive to the conditions, interactions among actors, strategies and tactics, and consequences in the documents as mentioned by Strauss (1987). With this sensitivity I built upon a number of existing concepts. For example, previously in the instructor handbooks I had glossed over the evaluation criteria for academic promotion. A closer analysis of the documents showed that every institution had an equivalent statement of the effect stating that teaching was their first and primary duty and that no amount of other activities such as research or community service could offset poor performance in the

classroom (United States Air Force Academy, 2019, p. 52; United States Military Academy, 2014, p. 16; United States Naval Academy, 2015, p. 40)(United States Air Force Academy, 2019, p. 52; United States Military Academy, 2014, p. 16; United States Naval Academy, 2015, p. 40). While a distinct definition of what excellent teaching was not exactly defined, teaching was the number one evaluation criteria for instructors. I also chose to treat these documents as the "official stance" on many aspects of instructor behavior and established their view of normative behavior. I passed through the documents again and was able to connect several aspect of them with existing concepts, thus continuing the axial coding of my data (Corbin & Strauss, 2008, p. 198).

While I did use a grounded theory approach, I must mention I did deviate somewhat from a pure Grounded Theory approach. Grounded theory called for theoretical sampling (Strauss & Corbin, 1990, p. 176) after the development of some concepts. I collected all of my interview data during field work and did not return to the field to select new interview participants after analysis had begun. This deviation was offset somewhat by the mixed method exploratory nature of my study. While I did not conduct additional interviews, I did explore concepts developed in the interviews in the next phase of the study with the online survey. Additionally, I also somewhat unknowing deviated from a grounded approach when addressing issues of power and hierarchy within the military. My background as an officer in the US military as provided me with over 20 years of both being told what to do by people in explicit authority over me and also telling people what to do who I held legal authority over. This experience and background made me perhaps more sensitive to the ways that commanders or teachers explicit or even unknowingly described the ways they influenced or held power over students or teachers. In this respect I was informed by examiners that I unwarily employed some of the elements of Critical Discourse Analysis (T. A. Van Dijk, 2015) during analysis of interview data. This concludes the discussion on qualitative methods, the chapter will now move on to a discussion of the quantitative methods and the development and use of an online survey.

3.3 Quantitative data generation and analysis

This section documents how I used an online survey to answer various aspects of the research questions. Section 3.3.1 begins with a discussion on the rationale for using a survey. Section 3.3.2

discusses how the quantitative data were generated which includes subsections, how participants were sampled and how the survey was devolved, piloted, and administered. Section 3.3.3 discusses how the survey data were analyzed with both univariate and bivariate analysis.

3.3.1 Rationale for survey research and participant sampling

The rationale for using a survey builds upon that provided in section 3.1.1. Primarily that survey research was determined as the best way to the research questions. It did this by confirming findings from the interviews as well as adding evidence to their variation in different military contexts. In further support, surveys are the next most commonly reported methodology for investigating beliefs about teaching (Gow & Kember, 1993; Kember & Gow, 1994; K. Murray & Macdonald, 1997; Prosser & Trigwell, 1997; Trigwell & Prosser, 1996) after interviews. The survey developed for this study also contained several open-ended questions that allowed additional aspects of teachers' beliefs, practices and influences to be explored. Lastly, the survey provided a balance of quantitative data to primarily qualitative study up to this point.

Participants for the survey were not be sampled, rather a census of the entire population was collected. With approximately 250 instructors teaching physics, chemistry, and biology in this setting, it was not unreasonable for all instructors to be provided the opportunity to participate in the study. Access to the participants was discussed in section 3.2.1 and gained prior to qualitative work.

3.3.2 Quantitative data generation

Survey question development

This section documents the development of the survey used in this study, included in Appendix B: Survey. The survey contained four sections with each designed to answer a different aspect of the research questions. The four sections included a demographics section, a section exploring beliefs about teaching, a section exploring teaching practices, and finally a section asking about various influences on instructor teaching development.

Survey questions were grounded in the findings from the analysis of interviews. In addition, past studies answering similar research questions (Kember & Gow, 1994; Norton et al., 2005; Prosser & Trigwell, 1997) and feedback during piloting contributed to its development. As this was the first

research survey that I had developed I frequently referred to Bryman's (2016, p. 241) chapter on asking questions. In particular, I made extensive use of his checklist for identifying issues with my questions (Bryman, 2016, p. 262). I also tried to consider how I would analyze each portion of my survey data after collection. After reviewing these best practices, I set to work creating the survey.

The background section was initially guided by demographic questions adapted from Norton et al's (2005) study on teacher beliefs . Some additional demographic questions were developed during the interviews and piloting. For example, military respondents often mentioned how their previous occupations prior to teaching within the military affected how they teach. In response, I added military background demographic questions as well. My initial questions were a bit vague and through the use of methods texts (Bryman, 2016) I corrected some flaws. Difficult language was also discovered in piloting. As an example, my background section originally contained several open-ended questions that were better answered with properly formatted multiple-choice questions. It was also possible to remove some confusion through the use of display logic as the survey was administered online. Demographic questions which were not applicable to certain respondents were filtered to avoid confusion. A question was also included that allowed any participant who had participated in the interviews to also identify themselves during the survey. This was employed to connect survey data with interview data where possible.

Questions on instructor's beliefs about teaching

The survey section exploring instructor beliefs proved to be the most difficult section of the survey to develop. This was mainly due to beliefs being more difficult to access than other topics such as practices. Prior to conducting fieldwork, I had planned to use the Approaches to Teaching Inventory (ATI) survey developed by Trigwell and Prosser (Trigwell & Prosser, 2004; Trigwell, Prosser, & Ginns, 2005). I chose this tool as it was an instrument developed for assessing teacher beliefs and it appeared appropriate for answering my beliefs related research questions. The ATI also had desirable characteristics such as being developed for use with higher education science teachers (Prosser & Trigwell, 2006) and had a long history of use (Harshman & Stains, 2017). After analyzing the qualitative data, I decided to discard the use of the ATI as my findings were leading me in

different directions as described in the qualitative data analysis section. I realized that there was no tool appropriate for probing the findings that I had uncovered in the interviews so I developed a new survey. During interviews other beliefs were expressed that seemed more interesting and relevant to the military setting which I chose to explore instead. The findings from the interviews have been given their own chapter but in short summary a key theme of service in teaching was identified with several different dimensions. Examples of these dimensions were military identity, camaraderie, purpose for teaching, and instructional freedom. Drawing back to the interview data that developed these themes, I developed several questions for each theme to explore instructor's beliefs about them. I utilized Likert style questions (Likert, 1932)that appeared as statements that participants could indicated their agreeance or disagreement with. Typical statements had the form of be "Good instructors should…" or "It is desirable for…" and negative statements were also included. In the first versions of the survey, I attempted to pursue too many themes and I generated too many questions. I had to heavily edit them guided by each question's utility in addressing a specific research question.

In addition to the Likert questions, two open ended questions were also added asking about what instructors saw as their purpose and what was the most important thing for students to gain from their classes. These questions paralleled some of the themes discovered but continued with the exploratory nature of the study. After completing the beliefs sections, I moved on to developing the practices section.

Questions on instructor's reported teaching practices

The next portion of the study consisted of questions seeking to measure the reported use of various instructor practices in the classroom that were identified from the interviews. These responses helped validate the interview responses as well search for connections between context and practices. Norton et al. (Norton et al., 2005) found that teacher practices or intentions were more influenced by their context than by their beliefs concerning teaching with their Teachers' Beliefs and Intentions inventory. For this practices portion of the survey, I began with the use of Norton's survey questions but discarded them by the end of the editing process. As Norton et al. (Norton et al., 2005) intentions section closely aligned with my research questions, I patterned several of my questions in a similar

manner. But the questions I developed were based on the activities and themes discovered during the interviews. Unlike the beliefs portion of the study, rather than indicate agreement or disagreement, respondents were asked to report how often they utilize a certain practice in their classrooms. The five options included: "never", "some lessons", "about half of the lessons", "most lessons", and "every lesson". The "how often" nature of the answers were to measure how often something happened as opposed to the beliefs question which typically took the form of agreement or disagreement. A free response option was included at end of this list for instructors to report any particular practice they utilize that wasn't listed. This was in maintaining with the exploratory nature of the study.

Questions on instructor's reported influences

The last portion of the study sought to understand the effect of different influences on the instructors' teaching techniques. These data were used to answer the research question investigating the sources of influence as reported by the instructors themselves. Like all previous sections of the survey, most the questions in this section were based on findings from the interviews. And also like the teacher practices section, a free response option was included for participants to list any significant influence that had not been covered.

Pilot study

After the survey was developed it was trailed it in a small (N=6) pilot study to test for clear language and to check for any obvious errors. The small size of the pilot study was part of an effort to balance the size of the pilot with the size of the population. The recommended size of pilot studies was based off what claims the study was trying to achieve (Johanson & Brooks, 2010). Some recommendations (Hertzog, 2008; Julious, 2005) being at least 10-12 participants per group. As there were 7 departments included in the survey, I anticipated this would result in a pilot study almost the same size as the actual study. This was made with the assumptions of population of ~250 instructors and an anticipated response rate of somewhere near 30% (Deutskens, De Ruyter, Wetzels, & Oosterveld, 2004; Ritter, Lorig, Laurent, & Matthews, 2004). In the end I chose to only pilot the study with six participants but to follow up each survey participant with a short interview. After each participant completed the survey in turn and feedback was incorporated. Most changes concerned

rephrasing some of the language. I was able to voice my concern about the inclusion of open-ended questions affecting the participation rate but several pilot respondents commented that those questions were valuable and allowed them to express options not available in the multiple choice. With a piloted questionnaire, I proceeded to the main survey administration.

Survey administration

I utilized an online survey distribution platform (qualtrics.com) for survey distribution. An email containing the CUREC approved participation request and a link to the survey was sent to a point of contact in each academic department. Each point of contact forwarded the participation request letter out via email to the teaching staff in each department. The points of contact were carefully chosen to avoid "command influence" that could be associated with high-ranking members of the department. This interesting military ethical aspect in regards to consent and is more fully discussed in the ethical discussion of this of this chapter in section 3.4. As I used the point of contacts as an intermediate step, I do not know the exact number of surveys sent out. Based on both information from points of contact and instructor rosters available from each department, I estimated the number of instructors at around 260. I requested follow-up email to be sent out at one and two weeks after the initial request. Data were collected by the online survey platform and available for immediate exporting. A total of 124 (47%) respondents began the survey but 23 stopped at various points along the way resulting in 101 complete surveys. After collection of the data, I began to analyze it as described in the next section.

3.3.3 Quantitative data analysis

This section describes how I analyzed the survey data in order to answer the relevant research questions. As discussed above, the quantitative portions of the study supported the findings from the qualitative aspects as well as compared different military contexts. This section discusses the response rate and missing data, how data were processed, and how free response items were coded. The following section discusses how univariate analysis was conducted. The last section discusses how bivariate analysis was used to identify differences in various groups.

Survey response rate, handling missing data, and data processing.

Of approximately 260 total instructors 124 survey responses were collected for an initial response rate of 47%. 8 of these responses contained no data and were eliminated. Of the 116 remaining responses, 14 participants submitted only demographic data before ending the survey. These responses were also removed as they did not contribute towards answering any research question and 102 responses remained. One response was identified to be a reattempt at survey completion and was removed. This resulted in a total of 101 responses with useable data representing a 38% response rate. Respondents that opted to not report on certain questions on beliefs, practices or influences were not analyzed on those factors.

The survey was administered through an online survey platform (www.qualtrics.com) and data were processed prior to analysis. Raw data files were exported directly from the survey website into a statistical software program (SPSS) (Field, 2013). A small amount of initial data processing was needed to convert multiple choice text responses to numeric form. The survey contained free response data in the form of open-ended questions. These data contributed towards qualitative answers to the research questions and were not utilized in the quantitative analysis. These free response data were coded qualitatively in the same process as described in section 3.2.3.

Quantitative data analysis: Mann-Whitney and Kruskal-Wallis tests for non-parametric data

Quantitative data was analyzed with methods that would provide the best answers to the research question "Do the teaching beliefs, practices, and influences vary between groups?". Demographic data was used to generate a number of groups and was categorical in nature. Likert responses were ordinal values and were treated as such (Allen & Seaman, 2007; Jamieson, 2004). This categorical data did not meet the assumptions required of parametric tests so non-parametric tests were utilized instead (Field, 2013, p. 213).

Mann-Whitney tests

Mann-Whitney tests, also known as the Wilcoxon rank sum tests, were utilized to compare the responses of two groups to each other (Mann & Whitney, 1947; Wilcoxon, 1947). This procedure

tests the null hypothesis that randomly selected values from two populations will be the same. This test is similar to the Students t-test (Pearson, 1895; Student, 1908) but does not require normally data and utilizes rank order data as opposed to mean data. Assumptions of the Mann-Whitney Test include 1) data must be randomly selected (satisfied), 2) dependent variable must be ordinal (satisfied), 3) groups must be independent of each other (satisfied) (Nachar, 2008).

The Mann-Whitney test statist, U, is defined mathematically by the following equations where n_x is observations in group and R_x is the sum of ranks assigned to that group.

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \qquad \text{and} \qquad U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

Mann-Whitney analysis conducted in SPSS (Field, 2013, p. 223) provided a Mann-Whitney test statist (U), a standardized test static (*z*-score), and the significance (asymptotic, 2-sided test, ρ). The z-score can be used can be used to calculate an effect size (r) with the following equation where N is the total number of participants (Fritz, Morris, & Richler, 2012; Rosenthal, 1991).

$$r = \frac{z}{\sqrt{N}}$$

Cohen (J. Cohen, 1988) suggests some effect sizes for r of:

r	Effect size
0.10 to 0.24	small effect
0.24 to 0.37	medium effect
0.37+	large effect

Mann-Whitney tests were used on almost every possible group binary group, examples include male/female, active-duty military/civil servant, and PhD/MS degree. Results are presented in Chapter 6 on differences between groups.

Kruskal-Wallis tests

Some groups consisted of more than 2 categories, examples include service branch, department, age, and teaching experience. For comparison across these groups Kruskal-Wallis tests were utilized (Kruskal & Wallis, 1952). These tests also utilized non-parametric data and are a similar test to tests of one-way ANalysis Of VAriance (ANOVA) tests but again utilize rank-order data. This

procedure also tests the null hypothesis that randomly selected values from several populations will be the same. Assumptions of the Kruskal-Wallis Test include 1) data must be randomly selected (satisfied), 2) dependent variable must be ordinal (satisfied), 3) groups must be independent of each other (satisfied) (Chan & Walmsley, 1997). Mathematically, the Kruskal-Wallis's test statistic H is calculated by the follow where N is the total sample size, R_i is the sum of group rank, and n_i is the group sample size.

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1)$$

Kruskal-Wallis tests were conducted in SPSS (Field, 2013, p. 236) and provided a Kruskal-Wallis test statist (H), and an adjusted significance (2-sided test, ρ). Unlike the Mann-Whitney tests, Kruskal-Wallis test that indicated significance required follow-up pairwise analysis (Field, 2013, p. 243). Follow-up analysis was conducted by examine every pair within the group. This pairwise analysis was very similar to the Mann-Whitney analysis and standardized test statics (*z*-scores), and adjusted significance (asymptotic, 2-sided test, ρ) could be used to calculate effect sizes (r). Results of the Kruskal-Wallis test are presented in Chapter 6 on differences between groups.

3.4 Ethical considerations and practical limitations of the study

This study was determined to be low risk and met all the ethical requirements by four organizations. In addition to the University of Oxford Central University Research Ethics Committee (CUREC) review [ED-CIA-19-060]. It met additional administrative ethical reviews at USAFA [FAC20190007H], USMA [19-046], and USNA [2019.0011-NE]. There were minimal risks involved with this study and all participation was voluntary.

One interesting finding that came out of the ethical reviews in the military settings should be discussed. It addresses the question if one could ever be an authentic volunteer in a military setting? There was a possible scenario where a participant might have felt forced to participate in a voluntary study simply because they felt it was their commander's intent. It could be reasoned that by even simply approving the study that commanders could be indicating an intent for their personnel to participate. A military euphemism for this scenario is being "volun-told", where one is a compulsory volunteer. The US Air Force Academy ethics office in particular was very explicit about the language

that could be used in my survey recruitment letter. I was allowed to say that the survey had been approved by the dean and their department head, but had to explicitly state that their participation or non-participation would not be reported to their chain of command. This was to ensure that command influence was limited. I took the additional step and explained this scenario to all interview participants to make sure everyone was authentically willing to participate. While this study was determined low-risk and generally instructors were happy to discuss their mostly chosen professions, it is still an interesting aspect of conducting a study with human participants in a military setting.

Another limit to this study is its generalizability. But this was less of a concern as the study was not designed to be generalizable. It is primarily concerned with an unexamined and somewhat niche population of science instructors in a very specific setting (Bryman, 2016, p. 163; Maxwell, 1992). Lastly, there are some limitations when working with beliefs as a theoretical framework. As discussed previously, beliefs cannot be directly observed (Pajares, 1992). As also noted in the literature review, it is unclear as to how beliefs relate to practices (Kane et al., 2002). This study has attempted to address this by asking about both beliefs and about instructor actions. The last limitation of this study to be mentioned is how instructor practices were only reported. Instructors could have been observed but this would have increased the scope of the study to greatly.

3.5 Description and demographics of study participants

Prior to the presentation of data on instructors' beliefs and practices, a brief description of the instructors and some of their demographic data will be provided. The purpose of presenting this description at this point is to provide some context and personality to the group of instructors who teach science at the US military service academies. Some of these data are presented again in chapter 6 when exploring the variance between groups.

As presented in section 3.3, there is a population of approximately 260 science instructors across the three service academies and 38% of them participated in the study. These science instructors taught the subjects of chemistry, biology, or physics. The first major distinction between instructor participants pertains to approximately half of the instructors being active-duty military

officers and the other half being employed by the government as non-uniformed civil-servants, see Table 8.

Table 8: Active-duty military versus civil-servant science instructors

Instructor type	Total
Active-Duty Military Instructor	53
Civil-servant Instructor	48
Total	101

While both groups are members of the US Department of Defense, the active-duty military instructors are officers, wear military uniforms, and have prior experiences in the military such as those described in section 2.1. Having military experience was not only limited to the currently active-duty military instructors as 17% of the civil-servant instructors also reported having served in the active-duty military prior to their transition out of uniform. Chapters 4 and 5 will detail how the two groups of military and non-military instructors were expected to contribute differently based on their expertise and experience. While both groups of instructors were expected to be excellent science teachers, the active-duty military officers were expected to make additional contributions as officer role models and civil-servant instructors were expected to make additional contributions as scientific experts in their fields. The active-duty instructors held less formal education and less science teaching experience than their civil-servant counterparts, see Table 9 and

Table 10.

Table 9: Education levels of US military service academy science instructors

Highest degree held? (count)			
	Master's degree	Doctoral degree	Total
Active-Duty Military Instructor	34	19	53
Civil-servant Instructor	1	47	48
Total	35	66	101

Table 10: Teaching experience of civil-servants and active-duty military instructors

Teaching experience at a service academy		
Years of teaching experience	Civil Servant Instructors	Military Instructors
0-4 years	11	39
4-12 years	11	13
12+ years	26	1
Total	48	53

The differences in experience and education are likely due to the active-duty military instructors having a primary occupation as a military officer. Due to a career management process described later in section 5.1, officers were typically either junior officers at the grade of O-3 or senior officers at the rank of O-5, see Table 2. Along with having less education and teaching experience military officers were typically often 15-20 years younger than their civil-servant counterparts, see Figure 6.

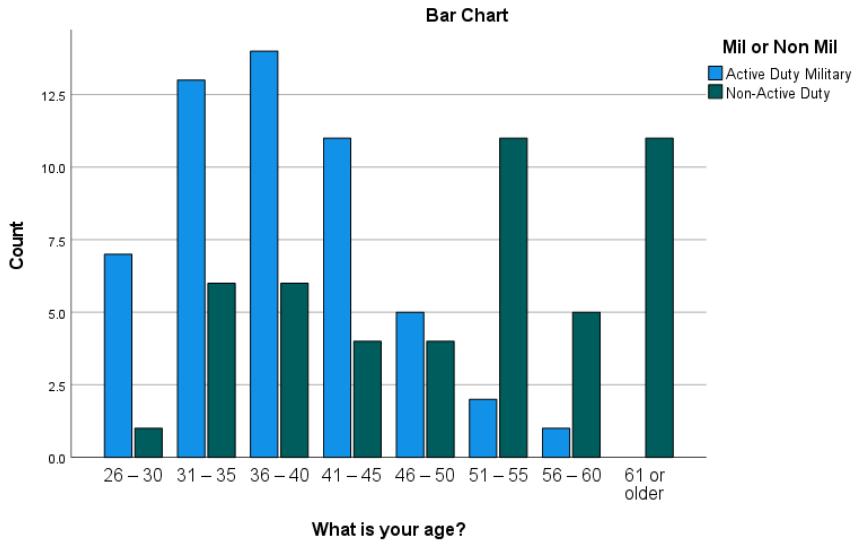


Figure 6: Active-duty military and civil servant instructor age histogram

Section 2.2 presented that teachers' beliefs are influenced by past experiences and can be resistant to change (Bryan, 2003; Kagan, 1992; Posner et al., 1982). This idea was used to present an explanation for why teachers might "teach the way they were taught" despite new evidence. Considering this position, it is perhaps useful to report that 50% of the active-duty military instructors,

representing 28% of all science instructors, reported being a graduate of a US military service academies and were taught science at an institution at which they now teach science. Finally, gender data was collected with 70% of instructors being male and 30% female.

This concludes the presentation of the methods used in this study. The chapter presented what rationale was used in selecting the methods and how the qualitative and quantitate data was accessed, generated, and analyzed. The next three chapters will present and discuss the findings of this study.

4 FINDINGS 1: BELIEFS AND PRACTICES OF SCIENCE INSTRUCTORS

Introduction to the chapter

This is the first of three findings chapters that answer the three research questions. Chapter 4 begins with section 4.1 and the presentation of evidence that supports the claim that a particular mission exists that appeared to serve as an overall influence for most beliefs and practices observed in this study. Section 4.2 then presents the findings on a number of beliefs and practices found in these unexplored military schools.

4.1 Mission: teaching as a way of preparing officers for military service

Section 2.1.1 presented literature to support the idea that within the military, the mission is the focus and guiding direction all activities are evaluated against. It is perhaps unsurprising then, that a mission of *preparing officers for military service* was the single most dominant and influential factor in understanding the data on instructors' beliefs and practices. This initial claim will be supported by evidence from official documents, the department leaders, and the instructors themselves prior to the exploration of other beliefs, practices, influence or variance. The central finding of preparing officers for military service arose from the analysis of the data. The following quote perhaps most succinctly summarizes the concept of preparing officers for military service.

> *"So, my view is that, first and foremost, we build leaders of character, and we do that through physics." – US Army, active-duty military instructor*

This view, or belief, was provided by an instructor when asked about the aims of education. They indicate that the foremost mission is to build leaders of character. In addition to their mission belief, the instructor also states that their approach to building these leaders of character is through the teaching of science, in their department the subject was physics. This belief in a particular mission was found across multiple sources and at all three military service academies. The follow excerpt reinforces the beliefs of instructors.

> *"The primary mission is [providing] an undergraduate education so that they can become officers" – US Air Force, active-duty military instructor and department leader*

This respondent used explicit mission language and expanded the mission to include not just their field of science, but the mission of the entire undergraduate education program for the purpose of

preparing officers. As interview data analysis proceeded and more accounts such as these emerged an investigation for the source of this mission was begun. The following sections provide the evidence for where this mission originates. While the sources were identified in a bottom-up sequence, they will be presented in a top-down manner.

As discussed in section 2.1, most militaries are not self-determining and do not set their own mission. As mission is generally passed down, it also could be traced back up to the highest level of the US government. Figure 7 was developed to graphically show the hierarchal and nested nature of the *mission* being passed down and interpreted from one level to the next. Each level will be discussed sequentially.

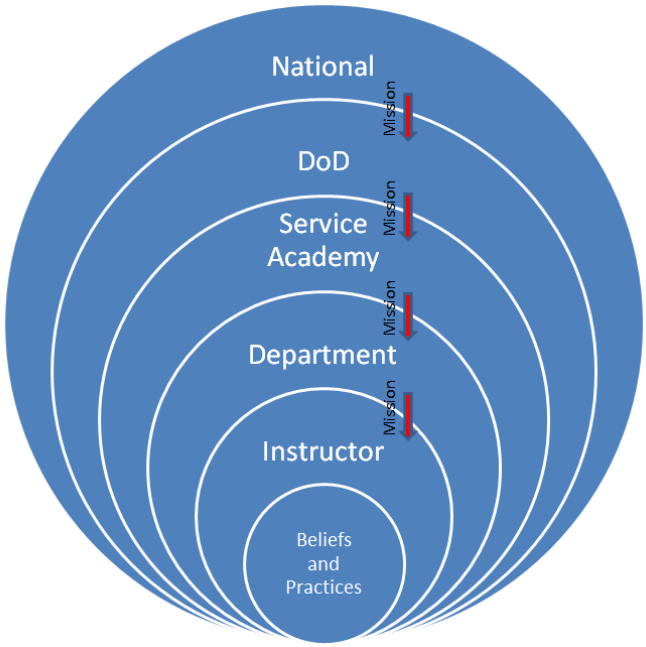


Figure 7: "Mission" being passed down to the science instructors from the national level.

Tracing mission back to its source led to the highest level of the US national government and a mission laid out in the US Constitution. The US Constitution is the supreme law of the United States and as outlined in article 2 of the Constitution (*U.S. Const.*, art II, § 2), the US Department of Defense's mission is "to provide the military forces needed to deter war and to protect the security of our country" (U.S. Department of Defense, 2022). Correspondingly, the DoD performs their mission through the use of a number of different sub-departments such as the Department of the Army, the Department of the Air Force, and the Department of the Navy as described in section 2.1. The DoD

also explicitly states the mission of each US military service academy in DoD instruction 1322(Department of Defense, 2015, p. 1):

> *"a. The academies provide, each year, newly commissioned officers to each Service that have been immersed in the history, traditions, and professional values of the Military Services and developed to be leaders of character, dedicated to a career of professional excellence in service to the Nation.*
>
> *b. The accession of those officers generates a core group of innovative leaders capable of thinking critically who will exert positive peer influence to convey and sustain these traditions attitudes, values, and beliefs essential to the long-term readiness and success of the Military Services."*

The DoD's mission includes a description of officers as leaders of character which was the same language used by the science instructor above. In describing what commissioned officers should be equipped with, ideas such as professional values, critical thinking, exerting positive peer influence to sustain the traditions, attitudes, and *belief* deemed essential to the military. It is likely that science teachers at these military schools see science as a key component in developing critical thinking. But it is important to note that the description of what is desired in a newly commissioned officer includes more than undergraduate education. This aspect is important to note when returning to the range of beliefs about teaching and practices found in military instructors.

After the mission was handed down from the DoD to each military service academy each re-expressed it in their own guiding documents. Table 11 presents the mission statements presented from each military service academy as quoted from their instructor handbooks. These handbooks represent the official views of each institution and could be considered organizational beliefs.

Table 11: US Service Academy Mission Statements

US military Branch	Specific Service Academy Mission Statement
Air Force	*"The USAF Academy's mission is to educate, train, and inspire men and women to become officers of character, motivated to lead the United States Air Force in service to our nation." (United States Air Force Academy, 2019, p. 34)*
Army	*"To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country; and prepared for a career of professional excellence and service to the nation as an officer in the United States Army." (United States Military Academy, 2014, p. 2)*
Navy	*"To develop midshipmen morally, mentally and physically and to imbue them with the highest ideals of duty, honor and loyalty in order to graduate leaders who are dedicated to a career of naval service and have potential for future development in mind and character to assume the highest responsibilities of command, citizenship and government." (United States Naval Academy, 2015, p. 15)*

While each statement is similar in many ways, it is also observable that differences between the branches of service begin to be observable at this point. The third research question seeks to understand how instructors'' beliefs about education and practices vary and one explanation might be that they vary based the specifics of the mission that is passed down. The Army and Navy list out the certain values they are seeking such as "duty, honor, country, loyalty" while the Air Force only mentions "character" but not what specific values those might be. In terms of service length, the Army and Navy discuss service as "career" while the Air Force makes no mention of a career. The Navy seems to take the concept of service one step further and describes service beyond that of in the military service as both in "citizenship and government". While these might be trivial differences in an institutional mission statement, differences in teaching beliefs about purpose involving concepts such as citizenship were found in the instructors. When stepping one level down and closer to the actual science instructor's additional guidance is given to instructors at each service academy. Table 12 contains statements from each school indicating the expectation of academic instructors.

Table 12: Academics and their role in the overall academy mission

Military Branch	The role of academic staff in context of the overall institutional aims.
Army	Our faculty must understand, support, and actively contribute to the implementation of this extensive and multi-faceted leader development program." (United States Military Academy, 2014, p. 2)
Navy	Naval Academy faculty members are expected to support the mission of the Naval Academy in all its moral, mental, and physical dimensions. (United States Naval Academy, 2015, p. 3)
Air Force	This mission is embedded within the very fabric of the institution, across all mission elements. Each faculty or staff member at USAFA plays a critical role in making that mission happen." (United States Air Force Academy, 2019, p. 34)

Each school affirms that academic faculty members focused in education are still called to support the entire officer development program. In this way the institutional documents seek to keep the purpose of activities in the classroom to be in alignment with institutional goals and the science departments' goals to be more clearly displayed. At this point it is possible move from documents back to the participants of the study. Following the hierarchy down would mean that the beliefs about educational aims should be examined in the leaders of the science departments.

Mission as expressed by department leaders

This section presents data obtained through semi-structured interviews describing department leaders' beliefs on the aims of education. The department heads (or chairs) were the leaders of their respective physics, biology, or chemistry departments and were responsible for leading their departments. A total of seven (five active-duty military, two civil servant) department leaders were interviewed across the three military service academies. The department leaders who were of active-duty military status all held the rank of colonel and had an average 32 years of military service. The civil servant department leaders had on average 21 years of service as instructors and leaders at their institutions. All leaders held terminal degrees in their fields and these individuals were charged with leading their respective departments of approximately 40 instructors and additional staff. During the interviews, department leaders articulated how their departments fit into the overall purpose of their respective institutions as well as their intentions and efforts to steer their departments towards achieving those purposes. Every department head indicated strong views in alignment with institutional goals. Here are two of examples.

> *"I never lose sight of the fact that the primary mission is an undergraduate education so that they can become officers in the United States Air Force. I've got to stay focused on that. I'm*

not producing physicists, I mean, I am when they're majors, but I'm producing officers, that's what I'm really producing" – US Air Force, active-duty military instructor and department leader

In this example, the department leader articulated the institutional goals as the primary mission of their science department. They stated that the science of their department was in support of preparation for a career in military service even when considering those students who chose to major in their academic discipline. The department leader also mentioned they had to stay "focused" on the mission. Later in the interview the same leader also indicated that they worked to keep their department equally focused.

"[I] ensure my department, which is my true span of control, is vectored as well as possible on a daily basis to accomplish the primary mission of graduating officers." – US Air Force, active-duty military instructor and department leader

This leader does emphasize that they actively work to ensure that the institutional mission is the unify focus of their education. This is one clear answer to the research question exploring the influences on instructor's beliefs and practices that the department leaders can be an influence. Here is another example from a different school.

"Mental, moral, physical, we have this threefold mission" – US Navy, civil-servant instructor and department leader

It was noted before certain subtle differences began to emerge at each military school when articulating the mission. This Navy department leader used the near identical language as their institution mission statement with a reference to mental, moral, physical. That institution's list is actually ordered moral, mental, physical, while the reorder was perhaps unintended, it might also be based on the increase in priority in the belief system of a leader in charge of a department focused on the mental component.

In addition to stating how they viewed their department's purpose at a high level, department leaders expressed beliefs on assessment. Below are two examples of how department leaders sought to identify what elements of their academic courses were vital for preparing officers.

"How do we develop our curriculum to serve our customer, which is the Air Force? …our students are going to go off and become officers, so what do they [need] from a foundational chemistry [course] and on up? …and are we providing that right education?... American Chemical Society exam scores should not be our only gauge on how well are we teaching chemistry" – US Air Force, active-duty military instructor and department leader

This department leader reveals beliefs about assessment and that their chemistry curriculum should not only be based on scores on a standardized exam produced by a scientific community, but also by the needs of an occupation as a military officer. While this leader mentions the customer as Air Force, it is also true that that leader had decades of service as a military officer and could draw upon their own experiences. Another leader at a different school articulated their broad experiences within the military and used that to distill what they believed to be the foundational skill to be developed in education as necessary for being a military officer.

> *I feel as if I've got a fairly full spectrum experience within the army, having served in every brigade type, and every operational type, And I've come to the conclusion that the unifying skill set of every graduate of West Point, quite frankly, all the service academies by extension, is you're a problem solver. Your job, whether it's the tactical through the strategic level is to solve problems of incredible complexity. If we don't tackle that issue on how to mentally prepare our graduates to deal with those ill-defined challenges, whether it's slow motion combat of counterinsurgency, or very rapid fire combat in high intensity conflict, that ultimately, as we integrate humans, and autonomous and semi-autonomous systems in integrated formations, we're not going to have the right army officers to solve those [challenges] and to lead those integrated formations or deal with ever more complex challenges that our graduates face. – US Army, active-duty military instructor and department Leader*

This leader has expressed their belief about the aims of science education and applied it to some extremely specific hypothetical scenarios. The belief that the purpose for learning challenging chemistry is to prepared an individual to conduct the slow-motion combat of counterinsurgency is a belief that is not documented in the literature. In a larger context of the interview, this statement was made in reference to the department leaders efforts to address what they believed was a shortfall in the intellectual experience of their students which they believe was caused by the widespread application of the teaching practice of process-oriented guided inquiry learning (Moog & Spencer, 2008). This department leader believed that the academic material associated with this teaching process was overly simplistic and would not provide the necessary rigor that would prepare student for complex challenges in military service. Like other department leaders, this leader was also actively working to shape their curriculum so that their graduates would be better prepared for a military profession.

Data from the documents and military leaders presented so far have supported the finding that at US military service academies, many science instructors believe that the primary purpose of science teaching is to prepare students for military service as officers. Furthermore, data from the department

leaders supports a finding that these instructors take actions to share their beliefs and influence those who teach with them in the department. The next claim that will be made is that not only the documents and leaders, but most instructors also shared the same belief about the aims of teaching science.

Mission as expressed by science instructors

This section will present evidence on instructor beliefs about their educational aims that was collected through interviews and open response survey data. It will build to support a claim that while many held identical beliefs to their leadership, a wider range of beliefs about the aims of teaching was collected that were in various levels of agreement with institutional mission statements

During the interviews, there was no specific interview question directed at exploring the aims of teaching or mission. Although instructors were not asked about their purpose, a number of beliefs about educational aims were volunteered during the semi-structured interviews and were often presented as part of an instructor's rationale for a choice or why they might utilize a particular practice. The following view was presented at the beginning of this section and is repeated here. The comment was provided in response to a follow-up question explore the participants view on a specific teaching philosophy.

> *So, my view is that, first and foremost, we build leaders of character and we do that through physics. – US Army, active-duty military instructor*

This statement was significant developing the theme that mission heavily influenced the aims of teaching. After the instructor expressed their belief, it appeared that almost all of their other beliefs and reported practices appeared to contained within a belief system (Rokeach, 1968) with mission at the center of it. Examples included how they managed students in the class, what science content they chose to present, and their choice of pedagogical methods. This theme of preparing officers for military service was found in most interviews and at every institution. Below is another example from the Air Force.

> *So, the chemistry itself, and this always baffles my students… the chemistry itself is not the important piece… the higher-level kind of problem-solving abilities and the ability to look at information and do something with that information… those are the sorts of skills that are going to get them through here, and that's the skills we want in their brain, when they get [into] active-duty. We need them to be able to solve problems. So that's my focus in the classroom here. – US Air Force, active-duty military instructor*

This instructor articulated a link between chemistry and active-duty service through direct terms of "the skills we want in their brain[s]". Not only did instructor have the key theme internalized but this instructor also expressed it to the students who were still "baffled" by it. Their comments also suggests that they hold a belief about students that they have not realized the purpose of their education yet. This instructor also mentions that desirable skill of problem solving that was expressed by a department leader at a different school. Following the design of a sequential exploratory research method, findings identified in the interview were more fully explored in the survey portion of the study.

During the online survey, data on purpose was collected in a free response question. Free response was selected for this item over a multiple-choice option as interview findings suggested that might be a range of beliefs about personal instructor purpose. Respondents were given the prompt "Complete the statement: My personal purpose at my institution is to…" A total 97 responses were collected from 101 respondents. Of the 97 responses, 51% of respondents explicitly mentioned the concept of preparing individuals for military service. Responses supporting the central theme were found at all three institutions and Table 13 contains a subset of these responses.

Table 13: Subset of Instructor Responses to "My personal purpose at my institution is to..."

USAFA	Further develop cadets into officers.
	Teach/prepare future AF officers the skills and knowledge they'll need to be successful.
	Prepare leaders, ready for life challenges and practiced in reasoning, communication and decision-making ethics
	Help develop officers of character, primarily (but not exclusively) through academic instruction in my discipline.
USMA	Advance the Academy's mission.
	Develop future officers, primarily but not exclusively through facilitating their education.
	Develop leaders of character *(3x)*
USNA	Develop officers who meet the Mission of the Academy.
	Demonstrate the value of science education in military operations
	Prepare my students for their military service and for their entire working career, in or out of the military
	To develop Midshipmen morally, mentally and physically and to imbue them with****(continues with institutional mission statement)*

While all beliefs presented in Table 13 are in alignment with each institution mission statements, they are expressed in different ways. Some instructors chose to indicate their purpose by simply referencing the mission statements such as "advance the Academy's mission". Other instructors chose to quote portions or the entirety of their service academy's mission statements such

as “To develop midshipmen morally…” Lastly, some respondents rephrased those mission statements into more personal reflections such as “Develop future officers primarily, (but not exclusively), through facilitating their education” that captured both the educational focus of instructor the yet their understanding that their purpose was not limited to simply academic content. But not all beliefs were in perfect alignment with the institutional aims.

Half of the responses did not specifically mention preparing students for military service. Of those that did not align, a majority focused on a combination of *teaching science* and a concern for the *personal development* of their students. Here are three such examples:

> *“Help cadets reach their potential and accomplish their goals while gaining valuable knowledge and skills about biology and how life works” – US Air Force, civil-servant instructor*
>
> *“Provide cadets with a fundamental thinking process to solve basic physics problems. Additionally, provide mentorship outside of classroom” – US Air Force, active-duty military instructor*
>
> *“Serve as a role-model to cadets and develop scientific thinking/inquiry” – US Army, active-duty military instructor*

These types of responses made up the bulk of the remaining responses. These instructors tended to describe their beliefs about educational aims in terms of focusing on the teaching aspects of their science and the thinking processes and inquiry valuable to their scientific field. They also indicated purposes that could be describe as a concern for mentorship, development, and role modeling, something expected to be found at a liberal arts college (Prince Jr, 2000; Van der Wende, 2017). While these instructors did not express beliefs about preparation for military service, they do not necessarily conflict with that aim. These personal purposes could be seen to be in alignment with institutional goals but just happened to omit the reference to future military service.

In summary, evidence was presented that both provided an answer to some of the research questions and also provided a lens with which to view much of the data. Science instructors at the US military service academies are likely to be aware of the institutions mission of developing officers and they have likely adapted this mission to serve as a belief for the aims of education. Data show that department leaders also embrace the institutional mission and they report sharing that mission in their departments. The rationale for this belief was extracted from evidence where instructors believed that

the critical thinking or problem-solving skills developed in studying science would translate into necessary skills of military officers. The next section (4.2) proceeds to further answer the research questions by presenting evidence for a wider array of beliefs and practices that exist at the US military service academies.

4.2 Instructor's science teaching practices and beliefs

The previous section presented data supporting a central theme of mission and preparing officers for military service, this section presents data from interviews and the survey as evidence to support additional claims about the beliefs and practices of science teachers at the US military service academies. These findings serve as answers to the study's research questions.

Section 4.2.1 presents identifies a number of teaching practices utilized by science instructors at military service academies. Section 4.2.2 highlights how typical science content was adapted to be presented in a military environment to military students. Section 4.2.3 presents several other constructivist teaching practices that were discovered. Section 4.2.4 presents evidence on how many science teachers at military service academies develop curriculum and practices that are not related to science, but rather to student development.

4.2.1 Science teaching: Instructor beliefs and reported practices

This section presents an overview of many of the instructor beliefs and reported practices discovered during the study. Evidence showed that instructors at the US military service academies used a variety of teaching practices when teaching science, see section 2.2.2. As predicted by the literature, traditional teaching practices (Kember, 1997; Mascolo, 2009) such as lecturing (Bligh, 1998) were documented. Other practices such as using illustrations, performing demonstrations, employment of survey response tools were also documented during teaching. Table 14 was developed from interview data using the instructors' words to identify a number of teaching practices.

Table 14: Reported practices in the classroom

Reported Practice	Quotes from interview participants
Lecturing	"I do a lot of lecturing" – US Air Force, civil-servant instructor
	"[I'm a] lecturer [but] you don't want to just be a lecturer. But there's something about listening to some person talk, and then understanding what they're saying, [it] is a skill they need to have." – US Navy, active-duty military instructor
Using real world illustrations to teach topics	"We talked about redox reactions, and we talked about batteries... why is your cell phone battery dead? How do we recharge it? What's actually happening?" – US Army, active-duty military instructor, course director
	"I try to bring in a lot of real-world examples" – US Navy, civil-servant instructor
Using in class demonstrations	"I'll blow up a hydrogen balloon, and we'll turn it into a chemical equation" – US Army, civil-servant instructor
	"We make a thermite grenade in class" – US Army, active-duty military instructor and department leader
Solving example problems	"because the kids love to see me demonstrate how to [solve] a problem, and then have them [solve] it" – US Air Force, civil-servant instructor

Table 14 illustrates the practices of lecturing, using examples, using demonstrations, and demonstrating problems for the purposes of teaching science. While lecturing is generally considered to be a traditional teaching practice, some of the other practices involving relevant examples, demos, and problem working are practices that begin to move from a purely traditional position of information transfer to practices considered to have an increased amount of student engagement. These teaching practices seem mostly unremarkable since they were already documented in the literature, see section 2.2.2, but are being presented as they are answers to the research questions. In Table 14, one chemistry instructor's practice of making a thermite grenade as an in-class thermite demonstration seemed unique. While thermite is a common demonstration in chemistry teaching (McGuire, Carroll, Boynton, Mendez, & Blake, 2015) it was described using military language typical of a weapon. More of these practices were identified and are presented separately in section 4.2.2 as they are a major finding of the study.

The practices in Table 14 were identified in the interviews and were further explored during with the quantitative survey, see section 3.3. The survey sought to explore this finding by identifying how many other instructors also used this teaching practice and with what regularity. Survey respondents were provided example teaching practices and asked to report their use through the options of "every lesson", "some lessons", "about half of the lessons", "some lessons", and "never. The data for the questions involving extended lectures, demonstrating solving problems, utilizing real-

world illustrations, conducting demonstrations and providing supplemental note packets and the responses are reported in Figure 8.

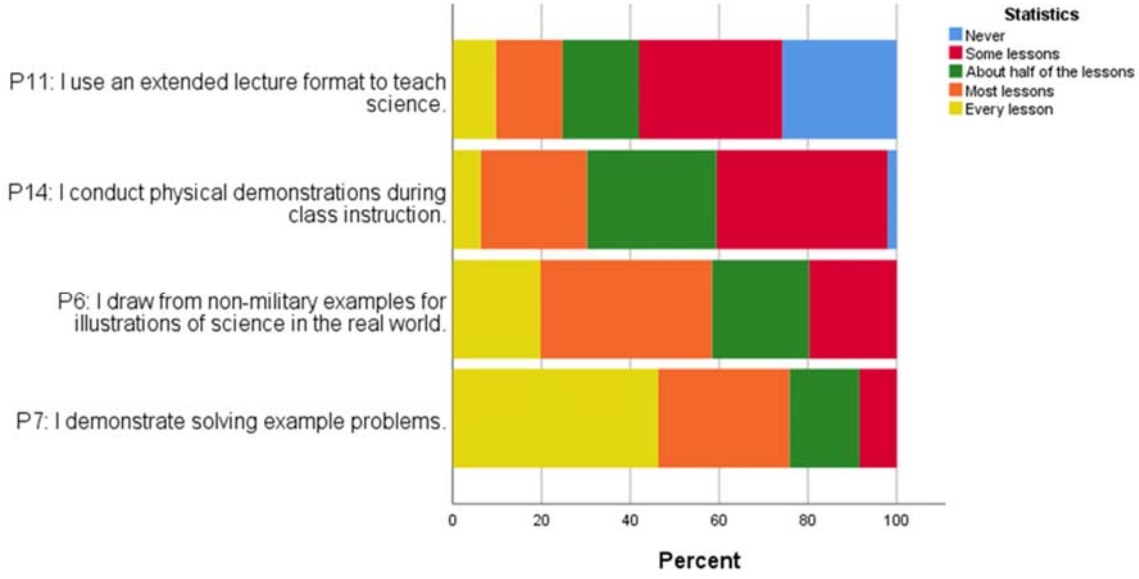


Figure 8: Content Delivery Practices Data (N=101)

Data in Figure 8 build upon the interview findings and explore the traditional practice of lecturing along with practices that could have occurred as part of a lecture. Question P11 indicates that about 40% of the science instructors at the US military service academies use extended lectures in half or more of their lessons. An increased percent of instructors conduct demonstrations during class, see question P14, and even more instructors use real world non-military illustrations during class, see question P7. Table 14 listed a real-world example where a chemistry instructor used mobile phone batteries as an illustration for explaining oxidation-reduction chemical reactions. Responses to Question P7 suggest that one of the most prevalent practices of instructors is the demonstration of solving example problems. This finding that was so prevalent that section 4.2.3 explores it more fully. The next section explores a relatively undocumented practice of science instructors adapting their science teaching to increase student learning a military environment.

4.2.2 **Science teaching tailored to a military student**

This section presents findings that many science instructors at the US military service academies tailor their science teaching practices to a military context. Several illustrations will be presented of how instructors weave military centered illustrations and experiences into their lessons.

A claim that will be developed is that some instructors believed that students would be more engaged if instruction involved examples more relevant to their future profession. The first illustration was collected from an Air Force physics instructor who previously served as a C-130 transport aircraft pilot. They described how while teaching about forces, they adapted non-military example into an example involving military aircraft.

> *"So, there was an example problem right out of the textbook that was about a dump truck on a sloped road. And I thought, yeah, we can do that. Or, we can do the exact same physics equations but I can give them a case study of a C-130 runway that I used to land on in Alaska that was on a 10-degree slope" – US Air Force, active-duty military instructor*

This instructor replaced a common "textbook" problem with a military example demonstrating the same principles of physics. As a visual aid, Figure 9 was developed by the author based on the instructor's description for how they adapted a textbook forces example to involving military aircraft.

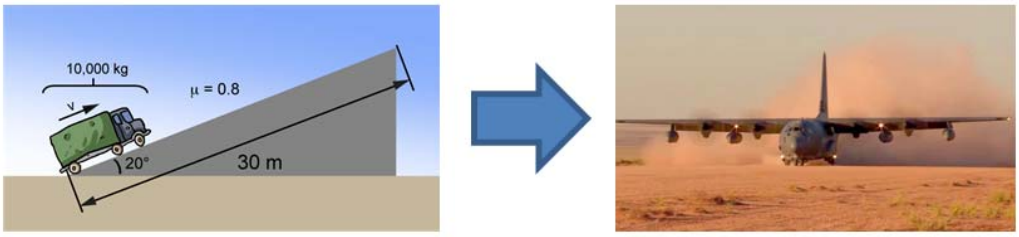


Figure 9: Physics example adapted from a dump truck to a C-130 military transport aircraft. Recreated by the author based on instructor's description.

Not only did this instructor use a military example, they used an example from their own experiences as a military aviator. The instructor's account of this teaching practice and their beliefs about its utility continue below.

> *So, we work a board work problem that's like that. And then I show them a minute long video of the approach into that radar site. And it is just a gravel runway in the middle of nowhere; there are no roads in or out, and it's eye opening to them when they see that. You're on the way to this mountain and then finally they see this little outline of a gravel strip. It's about a three-quarter mile long patch of gravel. And they say 'you land on that!' And that motivates the problem that hopefully they're a little bit more engaged when they're working it because now it feels like an Air Force example. Yeah, even though the equations that they're using are exactly the same as the ones out of the textbook for a truck on a road." – US Air Force, active-duty military instructor*

We find from this teaching practice account that the instructor not only adapted the physics problem to involve a military aircraft, but they further enhanced the scenario with actual video footage captured of the science instructor/pilot flying and landing at this austere runway. The instructor's account also reveals a belief that military relevant illustrations increase student motivation or engagement for a physics problem. They appear to rationalize this belief based on the students have an eye opening and surprise and how the exercise is no longer about a physics example but an Air Force example. Additional accounts were collected in the interviews. A second example comes from chemistry being taught in at US Army school. This instructor was teaching thermodynamics and uses an interesting example to connect the chemical concepts of oxidation-reduction reactions, standard reduction potentials, and Gibbs free energy were combined in a discussion of thermite and its application in a thermite grenade.

> *"The art form again is to bring the chemistry to life. So, for instance, in a redox class that I just taught, you know, when you build up all the redoxs, and then you're trying to link standard reduction potential to Gibbs free energy and the equilibrium constant, I like to kind of build up to 'Okay, let's see if we can apply this understanding to a thermite reaction. And then we make a thermite grenade in class, for real! And [we] actually melt the steel, and do it in a fume hood. And not only is thermite awesome! [but] you're tying it to something that they could practically employ in a tactical setting." – US Army, active-duty military instructor and department leader*

Thermite reactions are documented chemistry demonstrations (McGuire et al., 2015) and thermite is useful in applications such as thermite welding (Lonsdale & Engineer, 1999). This instructor not only recounts using a military example of thermite to teach several chemical concepts, but takes it an additional step by creating a physical demonstration in the classroom. The instructor mentions that this is something that students might actually use this reaction "in a tactical setting". The tactical setting referenced would be the use of the AN-M14 incendiary hand grenade combat, see Figure 10.

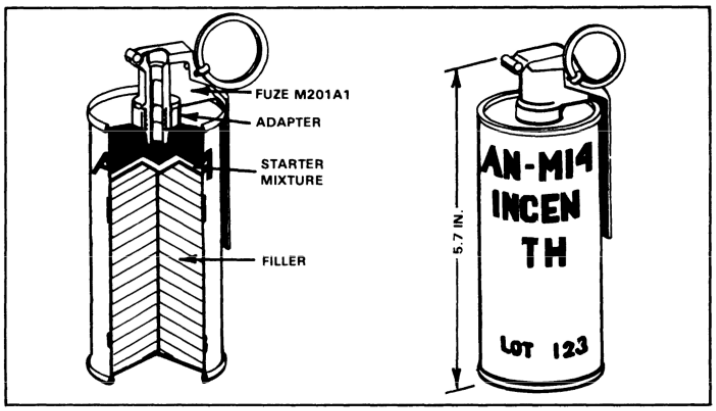


Figure 1-16. AN-M14 TH3 incendiary grenade.

Figure 10: AN-M14 TH3 Incendiary Grenade: a weapon that might someday be employed during military action but students in this chemistry class. Sourced from Department of the Army: Field Manual 23-30 Grenades and Pyrotechnic Signals 1988 (Page 20).

In an application different to welding, thermite in a grenade is used for the demolition of equipment, such as captured enemy artillery pieces on the battlefield (Department of the Army, 1988, p. 20). As members of the US Army, it is possible that these current chemistry students might one day be required to use this weapon in a combat setting. Similar to the Air Force example, this Army instructor believes these practices are both exciting and relevant and it seems reasonable to assume that they believe their students do to.

The previous two examples were not the sole accounts of such practices being reported during the interviews. Similar accounts were collected at every school, in every science department, and from both military and civil servant instructors. Evidence to support this claim is presented in Table 15 with the scientific concept, a brief description of the example and the military branch and science department.

Table 15: Science concepts as related to military technology

Scientific concept	Military Example	Service Branch
Electrochemistry	Calculation to determine battery performance as related to aerial drone loiter time	Army Chemistry
Electrochemistry	Specific metals used for corrosion control in aircraft paint	AF Chemistry
Electrochemistry	Corrosion control in Naval vessels	Navy Chemistry
Thermodynamics	Gunpowder energy calculations	Army Chemistry
Torque	F-15 fighter aircraft with fuel tank on only one wing emergency response time calculation	AF Physics
Acceleration	T-37 aircraft engine thrust calculations of time till takeoff speed on runway	AF Physics
Gravity	GPS satellites in orbit	Army Physics
Nuclear Chemistry	Uraninum-235 isotope enrichment for weapons development	AF Chemistry
Electricity & Magnetism	Naval aircraft carrier launch catapults and rail gun development	Navy Physics
Polarization of light	US Navy ship display monitors and USAF pilot glasses recalled	Navy Physics
Magnetism	Degaussing naval submarines to remove magnetic signatures	Navy Physics
Fluids and Buoyancy	Submarine surfacing and diving	Navy Physics

Table 15 contains a selection of the numerous data collected on how these science instructors work applications of military technology or situations into their science teaching. Military examples were connected to a broad range of scientific concepts in almost every area of physics and chemistry. As a prevalent finding in the interviews, this practice was also investigated quantitatively with the survey. Instructors were asked to report their use of military examples during science teach, see Figure 11.

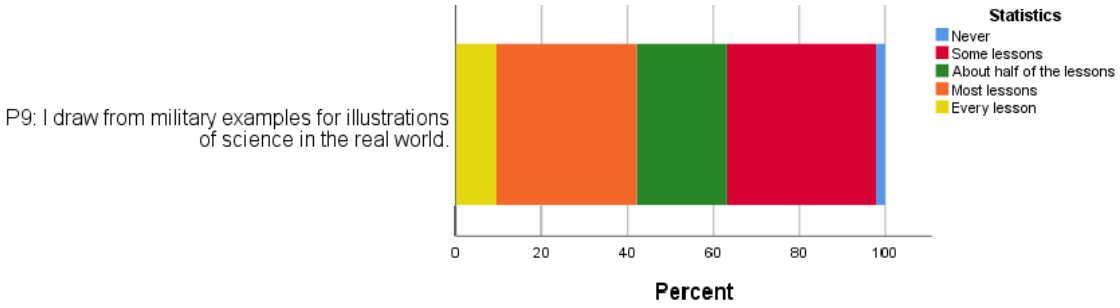


Figure 11: Reported use of military science examples (N=101)

Data from survey responses support the finding that this practice is widespread and over 60% of science instructors reported using it in half or more of their lessons and only a few percent indicated not use it. In comparing this practice to the practice of using non-military real world

examples, P6 in Figure 8, science instructors reported higher levels of non-military examples in their science teaching. A suggested explanation is that there are more non-military illustrations in textbooks and not all instructors had previous military service with which to draw them from.

One research question sought to explore and identify the influences of various teaching practices and beliefs about education found at the service academies. The author visited and toured each science department during their field work, and although it was an unanticipated data collection method, the author obtained permission and collected photos of several displays and posters hanging in the hallways outside of the classrooms. The pictures were analyzed as documents produced by the departments and were regularly seen by both students and instructors alike. Six posters and displays from the US Army's physics department and the US Air Forces' chemistry department will be presented. A short description of the science contained and military application is provided in each caption.

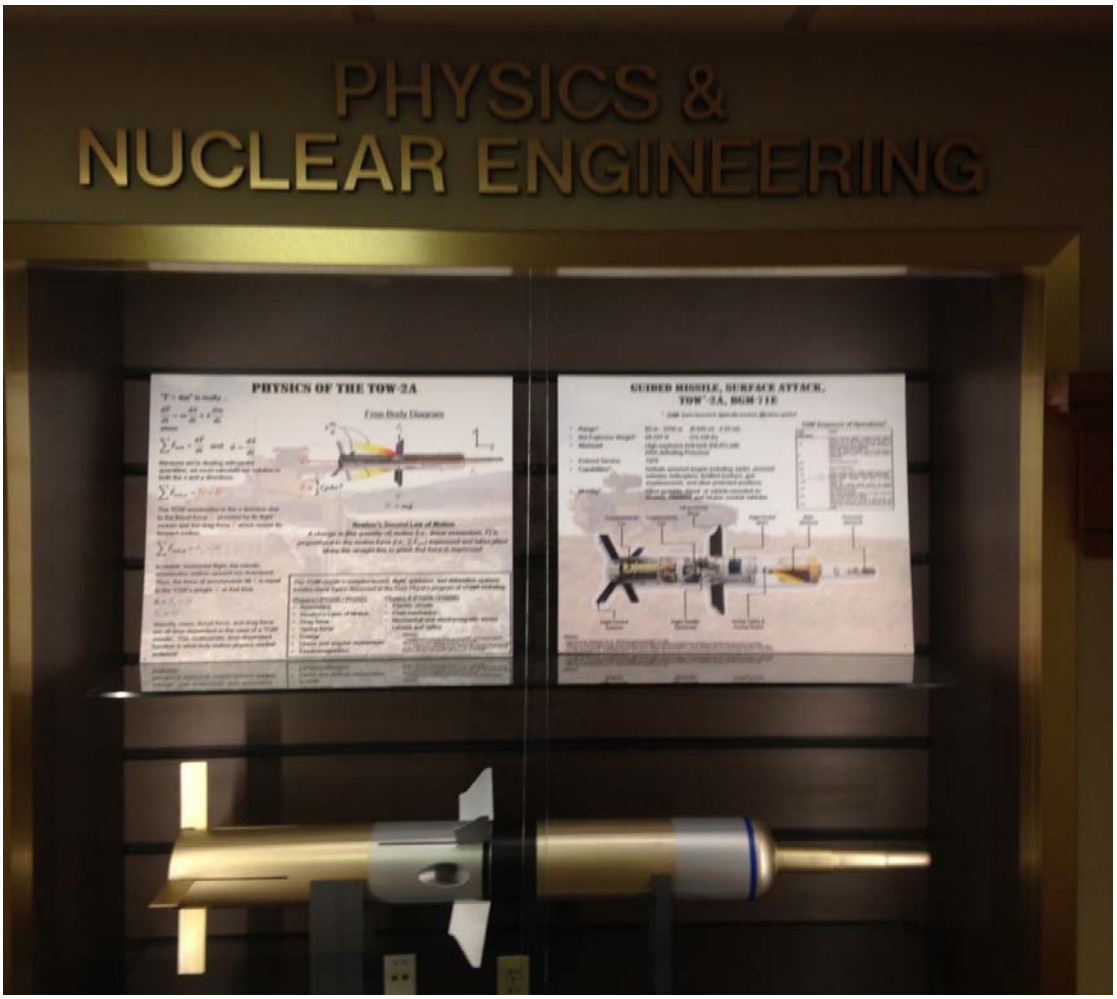


Figure 12: This photo captures a display containing the physics of F=ma explained and applied to the TOW-2A anti-tank missile. The poster on the left provides science information such as a derivation and free body diagram while the poster on the right provides the missile's tactical information such as range and weight. A model of the anti-tank missiles sits in the foreground of the display. Photo located outside of a physics classroom and obtained with permission from the US Army's Physics department.



Figure 13: This photo captures a poster illustrating the application of electromagnetic radiation (microwaves) in the personnel Active Denial System. The bottom right square explains concepts such as wavelength, radiated power loss following the inverse square law, and interaction of microwaves with human skin. The upper left square explains how such a system can be employed in combat to provide a defensive area through the use of intense non-lethal pain. Photo located outside of a physics classroom and obtained with permission from the US Army's Physics department.

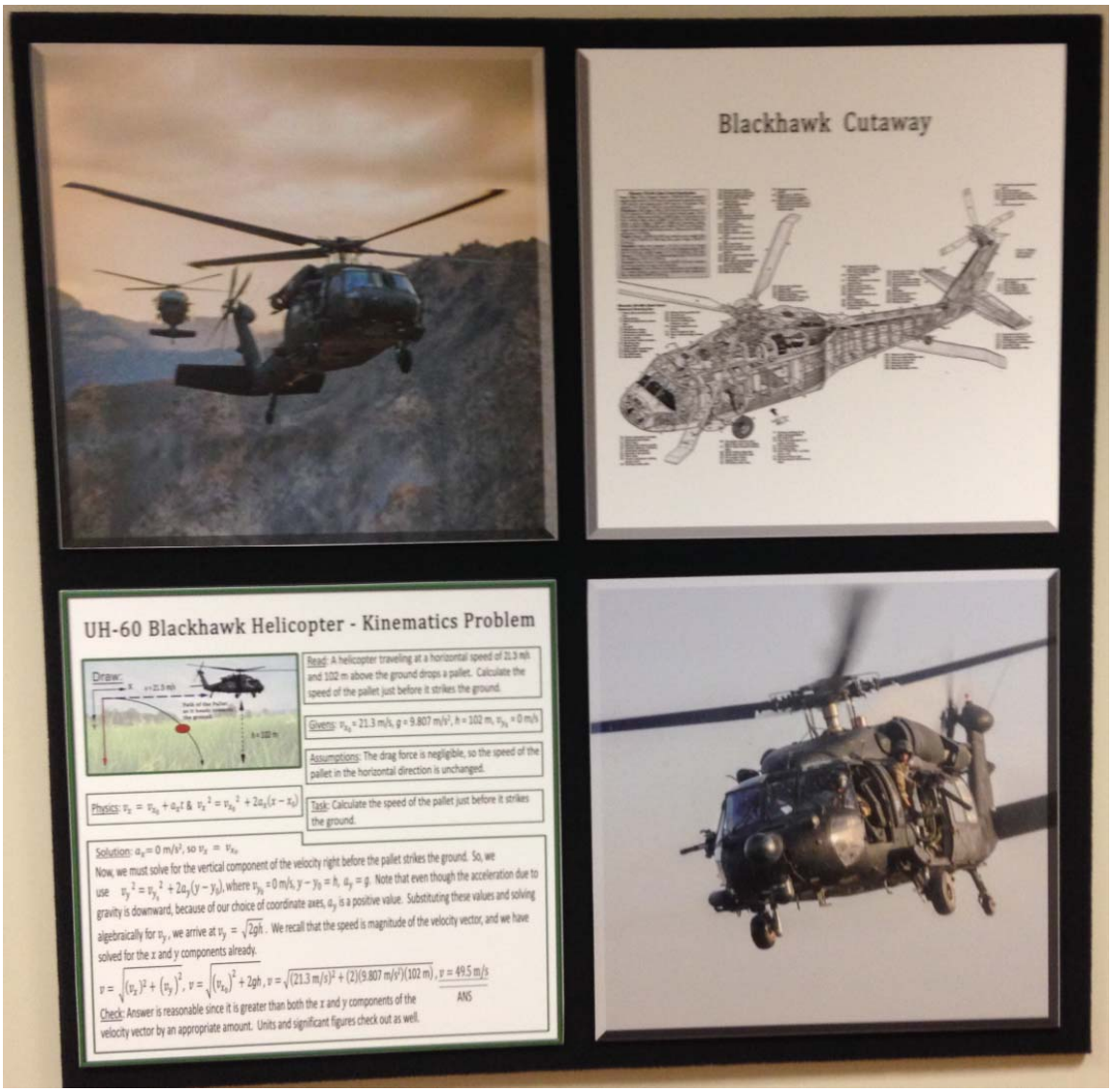


Figure 14: This photo captures a poster illustrating how the speed of a pallet dropped from a UH-60 Blackhawk can be calculated using kinematics. The bottom left quadrant works through the physics calculations. Photo located outside of a physics classroom and obtained with permission from the US Army's Physics department.

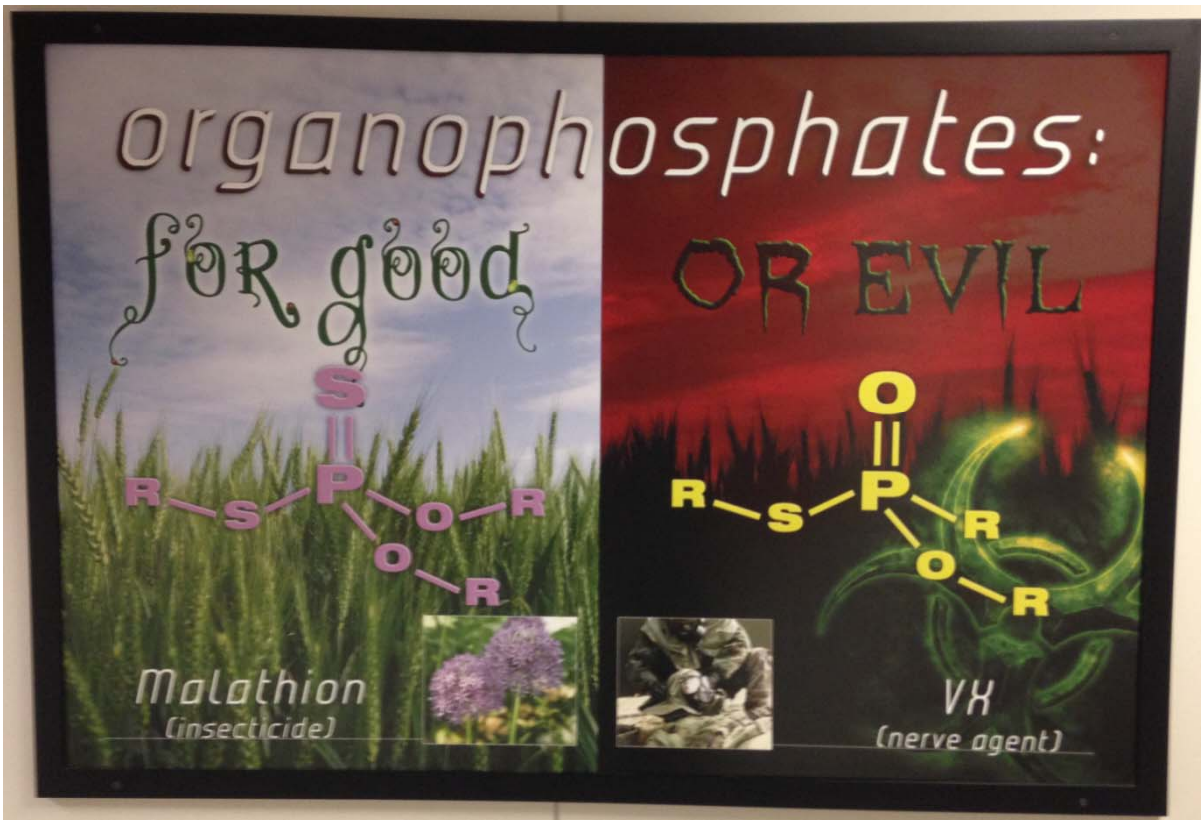


Figure 15: This photo illustrates the chemical structures of an insecticide and the highly toxic VX nerve agent. Although the poster has few words, the structures of the two molecules are positioned side by side to illustrate how replacing a single atom in an insecticide molecule can result in a very different new compound that is classified as a weapon of mass destruction. Photo located outside of a chemistry classroom and obtained with permission from the US Air Force's chemistry department.

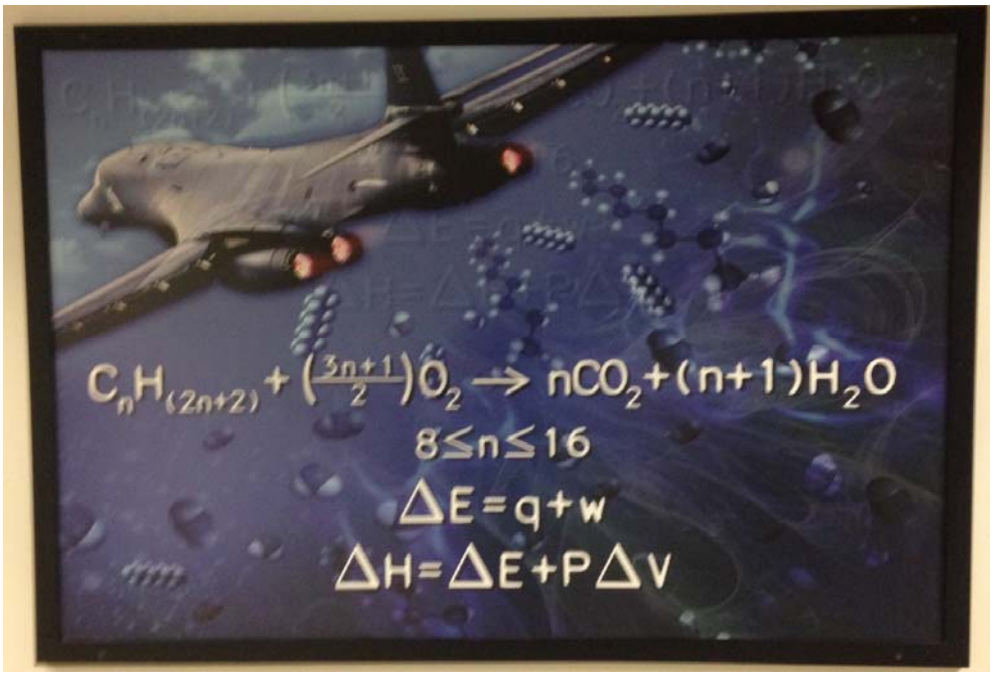


Figure 16: This photo illustrates chemical thermodynamics in the context of jet fuel combustion in the B-1 Lancer heavy bomber. The reaction of hydrocarbons and oxygen is presented along with energy calculations. Photo located outside of a chemistry classroom and obtained with permission from the US Air Force's chemistry department.

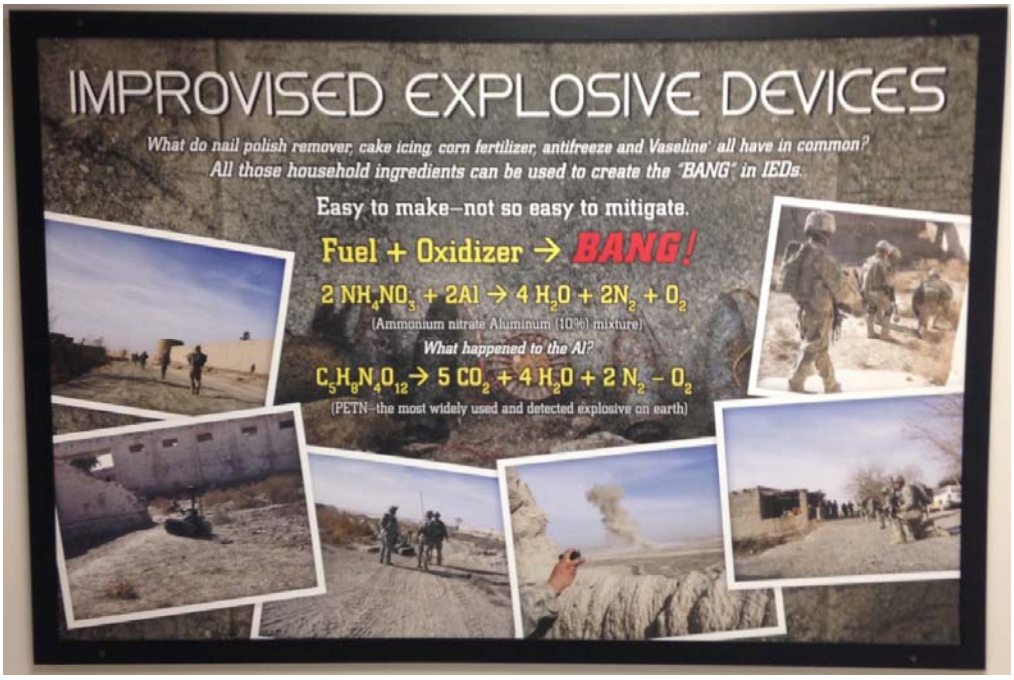


Figure 17: This poster shows the chemical reactions for two explosive substances. The chemical reactions are surrounded by images of US military soldiers neutralizing enemy improvised explosive devices. Photo located outside of a chemistry classroom and obtained with permission from the US Air Force's chemistry department.

The previous six figures serve as additional evidence of the practice of teaching science using military applications. But these posters might also act as an influence on what practices should be used by instructors. The posters were found in the hallways outside of classrooms, an instructor walking by might notice them repeatedly on their way to and from class. Being on display, these posters serve as a type of advertising for these types of illustrations of science. Since the posters were also placed in the hallways by the departments they could be interpreted as the preferred teaching approach of the department itself. In a military setting, the official position of an authority source can easily be interpreted as a directive, see section 2.1.1. While informative to students, these posters might also influence which teaching practices are used by instructors, which would be a part of the answer to the second research question.

In summary, this section provided evidence to develop the finding that science instructors as the US military academies adapt their science teaching practices to the military environment. Some of the rationale in the data for this practice is that some instructors expressed the belief that students would be more engaged in learning if the examples were more relevant to their own life. The next section will examine additional instructor practices that were intended to increase student engagement and learning.

4.2.3 **Beliefs and practices focused on increasing student activity**

The previous section presented evidence on instructors' beliefs about teaching in a military setting. This section shifts to the presentation of additional evidence on the various instructors' beliefs and practices explored in this study.

In order to explore both the beliefs and practices two questions were included in the interview. How do your students learn science best? And, how do you maximize student learning in your classroom? Data will be presented to support the finding that this study's teachers generally believed that students learned best when they are engaged. In the words of the instructors:

> *"I try and have that interactive engagement. I think they learned better from that. I think unfortunately, the structure of school for so many years; people think just notes are okay, which is one thing. But I don't think they learn as well" – US Army, active-duty military instructor, physics*

> *"But I think the best thing that I can do, at least as a faculty member, is get them engaged and work with them in a one on one, you know, even though it's like 19 students per class, but I*

can try to get them engaged and excited about the material." – US Army, active-duty military instructor, chemistry

Both instructors specifically mention their beliefs in the value of engagement. These specific beliefs about student learning is common (Kahu, 2013; Kezar & Kinzie, 2006; Kuh, 2001) and appears to be in agreement the idea of student-centered found constructivist beliefs and practices (N. W. Brickhouse, 1990; Haney et al., 1996; Levitt, 2002; National Research Council, 1996; Wieman, Perkins, & Gilbert, 2010). When examining this belief about engagement, it appeared that some instructors considered the student engagement to be generally internal to the student. In returning to the previous section's example of instructor's practice of replacing the dump truck with a C-130 military aircraft, they said "*and that motivates the problem, that hopefully they're a little bit more engaged*". This and the other examples of adapting science to a military environment appeared to be about increasing the student activity generally while they were listening to an instructor. The following section presents how other instructors believed that student engagement needed to be confirmed with some sort of external activity.

The above two accounts placed engagement in the context of being interactive or one-on-one. The second instructor reported that even with 19 students in a class, they were able to have individual interactions. This is an example of how a school policy such as class size might influence which teaching practices are utilized (Henderson et al., 2011; Neumann et al., 2002). From other instructor accounts we can extract beliefs about what kind of engagement is effective engagement.

"If they're not actually pushing the pencil, it's not really sticking" – US Navy, civil-servant instructor and department leader

This instructor holds a belief that if the student isn't pushing a pencil, then the information is unlikely to be retained. Other descriptions of physical engagement could be found in the data, sometimes it was referred to as work, or "doing it" or being "hands on".

"You can't get good at it if you don't actually do it." – US Air Force, civil-servant instructor

"I grew up in the age where the teacher stood up there and lectured and you took notes as fast as you could. They sometimes wrote on the chalkboard and you just kept doing all those things. Fortunately, I chose a science, biology, which has to be hands on. It has to be." – US Air Force, active-duty military instructor

These instructors held beliefs that learning, in the form of "getting good", has an active component and must be completed through student activity. Beliefs that students have to practice it ("do it") or work out sample problems on their own ("pushing the pencil"). In the last example the instructor believed that the study of their science, biology, was only accessible through a "hands on" approach and that there was a physical component required in learning the subject. Instructors held beliefs that engagement and activity on behalf of the student were necessary, next will be the individual practices they employed in creating engagement and activity.

Question asking practices during lectures

An observed, but unremarkable, instructor practice was the application of the Socratic method during regular lectures (Brickhouse & Smith, 2009). Numerous instructors reported the practice during interviews.

> *"So, trying to make sure students are engaged if I'm in a lecture context, the way I do that is, I'm always calling on people, typically I just go through the rows" -Air Force Instructor*

> *"I do a lot of lecturing, but I do a lot of questions. I do a lot of clicker questions"*
> *–Air Force Instructor*

Nearly all instructors reported this teaching practice. Some accounts included questions to the entire class for anyone to answer, other instructors reported "going through the rows" to directing questions sequentially to all students. Other instructors reported involving all students through the use of student response systems or clickers (MacArthur & Jones, 2008). This widely reported practice in the lectures was also widely confirmed in the survey. Approximately 90% of instructors indicated that they attempted to include lots of questions during their lecture time, see Figure 18, making it the most reported practice in the survey.

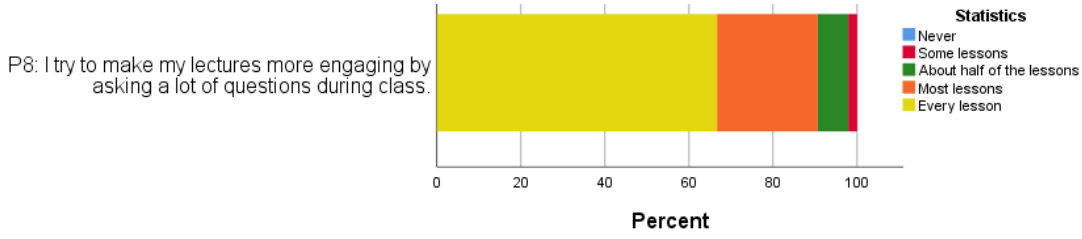


Figure 18: Reported question asking practice statistics (N=101)

Asking questions or calling on students during lecture was widely reported but it wasn't the only questioning practice. Another type of formative assessments described as extended problem solving by students at the white boards was also reported among instructors.

Problem solving practices in the classroom: board work

The extension of questioning students during lectures was assigning problems for students to solving during class time. One variation of this practice reported across all three schools was termed board work by the instructors.

> *Don't lecture at your students, make them do something; get them at the boards to work problems. -Army Instructor*

Teachers described this practice as sending students up to the white boards or chalkboards to work out various problems where the instructor, and everyone else, could see the entirety of their work. The practice was generally described as something that all or most students would engage it at the same time. Here are some accounts of its use.

> *"So, I just try to hit everything, notes, demonstrations, examples, with them. And then I send them to the boards just reinforce it, and have them work problems on their own. To me, that method works better, I feel like they get a better understanding if they're actually working through the problems themselves individually. – US Army, civil servant instructor*

> *"I think the single technique that is most effective is board work, getting them out of their seats, putting them at the board, where I can walk around and touch each group every few minutes to see their work, I can see where they're stuck… and it puts them on the spot where they have to be active." – US Air Force, active-duty military instructor*

In these accounts instructors express a belief about the utility of this practice and its effectiveness. The first instructor saw board work was as a reinforcement for the lesson. The instructor believed the practice of students being engaged and completing a problem on their own worked better than a lecture demonstration performed by the instructor. The Air Force instructor also expressed a belief about the teaching practice being the most effective. Their account had students work collaboratively in groups and the instructor describe moving from group to group evaluating work and helping groups that were stuck. The "on the spot" reference is likely connected to the established practice of "on the spot corrections" within the US military (Duarte, 2014). Military members are often encouraged to make corrections as soon as they are identified, or right there on the spot... Lastly, this instructor also mentions that during board work their students have to be "active."

The idea of active learning being interpreted as psychically active appears to be held by this instructor. While they certainly would have increased physically activity getting out of their seats, it would be interesting to know if this practice also translated into increased active learning on behalf of the student (Bonwell & Eison, 1991).

Board work seemed to be an adapted form of a recitation type class that the instructors perceived functioned well in this military context. Higher education science courses in the US often use large lecture seminars where material is presented to hundreds of students at a time (Deslauriers et al., 2011). These lectures are coupled with a recitation class where approximately 50 students meet to ask individual questions and practice problem solving with a less experienced instructor or teacher's assistant. In an institution with class sizes typically less than 25 students, the aspects of both lecture and recitation are combined into one and in this scenario board work seems a feasible practice. This practice would also only be feasible in a classroom with writing surface for all students. This practice was likely influential in classroom design at the military service academies as each classroom had writing surfaces on a majority of their walls.

The second research question explores the influence on teaching practices and beliefs. If beliefs can be shaped by past experiences (Fives & Buehl, 2012; Pajares, 1992), then perhaps this is both a teaching practice and a belief about education that has been shaped by instructors with previous military experiences. It is common when learning a new skill within the military to be required to demonstrate proficiency at that skill in a hands-on fashion. An example of this might include firearms training, a training that the author has completed on several different occasions. All new service members are required to complete some amount of weapons training during their initial basic military training. Weapons training often begins with a small lecture and orientation on the proper use of that particular firearm. After the classroom style lesson, students are required to form up on the firing line and correctly fire their weapons at a target. Firearm instructors move up and down the firing line during this time and make on the spot corrections as needed, see Figure 19. When it is time evaluate proficiency, assessment is conducted in mass and in public with trainees placed side by side. The description of board with students demonstrating physics proficiency side by side at the white boards while an instructor provides on the spot corrections appears to hold several similarities to weapons the

description of weapons training. The practice of board work suggests a finding that teaching practices used at the US military service academies are influenced by training practices with the US military.



Figure 19: Trainees practicing marksmanship training while receiving feedback from an instructor (Image from (Trudell, 2019))

One Army instructor provided their account on the origins of board work. They mentioned that the practice was a part of the "Thayer method," a set of pedagogical beliefs and practices native to the that particular institution. Research on the Thayer method yielded a historical account of Sylvanus Thayer. Brevet Brigadier General Sylvanus Thayer was the Superintendent of the US military Academy from 1817-1833 and was hand selected by the forth US President James Madison to implement a number of reforms to the institutional program (Shell, 2002). Thayer introduced a number of rigorous practices to the school including the original practice of recitation "at the boards". This teaching practice and the Thayer method appear to have survived over 200 years since their introduction. Figure 20 adds photographic evidence of the practice occurring oven 120 years ago.

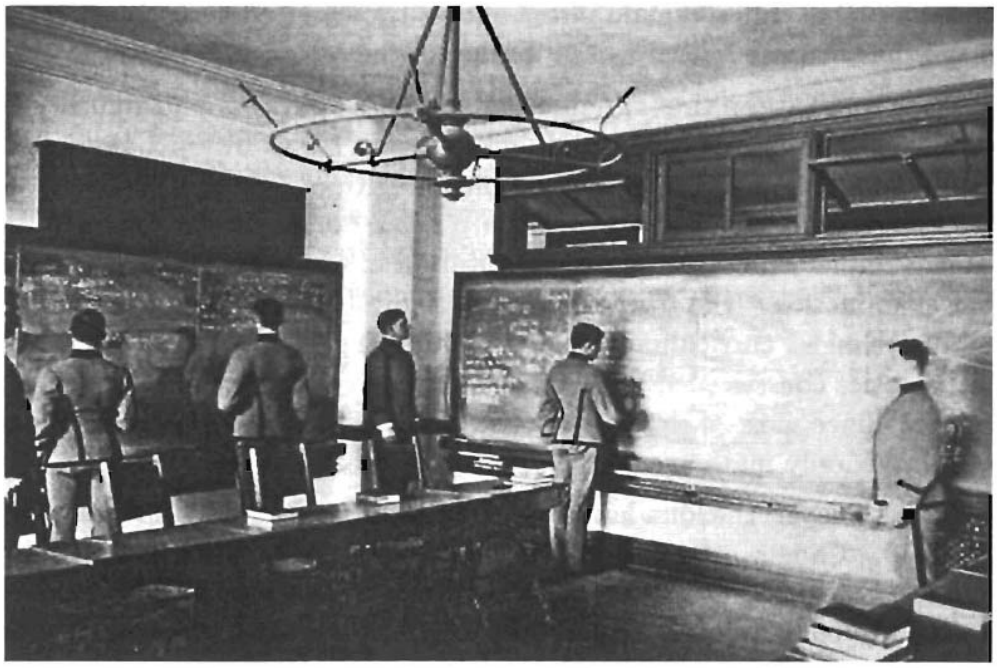


Figure 20: Students practicing “at the boards" circa 1900. Picture from (Shell, 2002) and provided courtesy of USMA archives.

Board work and dedicated time for problem solving was further investigated with the survey. Almost 70% of instructors reported dedicating time for students to utilize such teaching practices on most lessons.

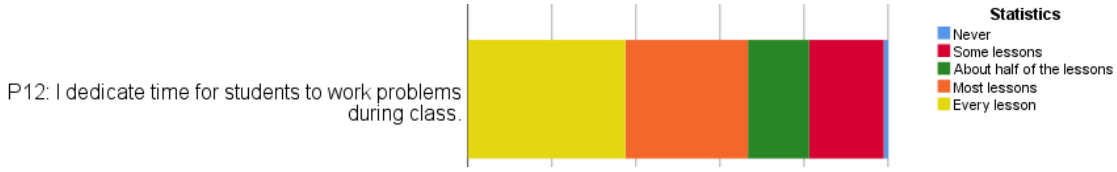


Figure 21: Statistics of instructors dedicating time to students solving problems during class time.

A previous account of board work described students as working in groups. The next section explores teaching practices that involved social or cooperative learning between students.

Practices and beliefs involving peer instruction

During the interviews, some instructors reported using teaching practices that emphasized cooperative learning or peer instruction (Lumpe et al., 1998). These were practices identified as constructivist in nature in the literature review (Dragisich et al., 2016; Prince, 2004). Here is one instructor’s account of cooperative learning.

> *"Well, the one advantage of POGIL is that you have a lot of cadets teaching other cadets the material, if a cadet can explain it to another cadet, it's your instant feedback loop." – US Army, active-duty military instructor*

This instructor utilized the process-oriented, guided inquiry learning (POGIL) pedagogy where groups of students would work together on a guided inquiry style lesson. This instructor's account illustrated their perceived benefits of the practice in terms of providing formative evaluation. Another instructor also expressed their beliefs that it was beneficial to allow students to teach each other.

> *"I saw one student showing the other student how to do it. So, either he was afraid to ask me, or he realized that he could learn from his peer. And it seems that when they teach each other, there's some goodness that happens there" – US Army, civil servant instructor*

This dialog segment was part of a larger discussion in where the instructor was explaining how they intentionally only provided information on how to set up a particular piece of lab equipment one time. The instructor reported telling their students "I'm not explaining this again" in order to encourage students to build self-reliance as well as community amongst their peers. It's also possible this instructor was simply desiring their students to pay close attention the first time it was explained. But describing peer instruction as "goodness", this instructor was approving of students working together. Another example of peer instruction was presented by a relatively novice instructor.

> *"I have these [PowerPoint] slides? I would say a good half of them are peer instruction. So, they have to talk to their neighbor and convince them that they're right, that their answer is the right answer to whatever I've posed up on the board…So peer instruction is huge for a teaching technique. Because the students are talking at their own level, sometimes I can't get down there, I'm too stuck in the material. I think I'm explaining it as easy as I possibly can and then I hear someone else's [explanation], and they actually teach me" – US Air Force, civil-servant instructor*

This instructor reported a significant use of peer instruction and how it benefited their students and also how it helped them grow in their teaching abilities as an instructor. The instructor expressed the idea that often they were "stuck" too high in the material and consequently were unsuccessful at translating their knowledge "down there" to the lower level of their students. But when the instructor overheard one student explaining a concept to another student, they were able to adopt the more readily understood explanation into their own teaching.

But the data also suggested that not all instructors shared harmonious beliefs on the utility of peer instruction. These next examples come from two instructors within the same department teaching the same course that had conflicting view of peer instruction.

> *"Where [in] peer to peer, I found that even a team of four, maybe none of them really knows how to do it. But they will all figure it out together. And I think that's way more powerful than me just trying to just spout out at the mouth, they get tired of it." – US Army, active-duty military instructor #1*

> *"One of my mantras that I've offered folks is, before you start working as a collaborative team, you got to bring individual competence to bear. If you're not individually competent, then you have no business or ability to contribute to a collaborative team. ...I am not a big believer in socially constructed knowledge" – US Army, active-duty military instructor B #2*

These two instructors held similar military backgrounds and both were fairly high-ranking officers and held fairly opposite views of peer learning. The first instructor held the belief that a group of students would be able to "figure it out" together even if no individual knew how to solve the problem. The second instructor held the opposite beliefs about the value of group work and mentioned their opposition to the idea of socially constructed knowledge. This instructor held that for peer instruction to within a collaborative team, every individual needed to bring some competency to the table. It is possible that these two military instructors were both were approaching the practice of group work based on their different military perspectives. The first instructor had a background in the military intelligence community. This position would have them often working to generate planning intelligence at the tactical or operational level to pass over to operational components who could conduct operations based on that intelligence. This instructor didn't assume that their students had zero know about the topic but simply that they didn't "really" know how to solve something. Similarly to the intelligence community, by the students pooling their partial bits of knowledge they could build enough knowledge that understanding could be achieved.

The second instructor came from a much more operational background and was responsible for assembling teams for the purpose of completing combat missions. As risk in any combat mission has grave consequences, any lack of expertise on a team member's part could have equally serious consequences. Thus, it's possible the instructors believed these members had "no business" being a part of a team. When approaching building groups and peer-instruction in the classroom this instructor seemed to apply the same cautions even though a team working in a classroom has vastly different

consequences than in an operational combat mission. These finding contribute to answering the research questions in that instructors held different, sometimes oppositive beliefs about certain teaching practices and that their beliefs might have been influenced by their previous military career experiences.

Despite instructors holding different beliefs about the social construction of knowledge, accounts of peer instruction were regularly reported. This teaching was also included in the survey and results in Figure 22.

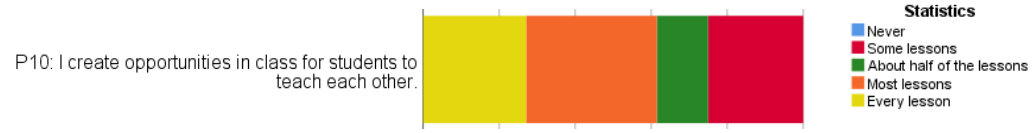


Figure 22: Statistics for reported use of peer-instructional techniques

Survey data indicated that 60% of instructors reported created opportunities for students to teach each other on most lessons or more. Even with some negative attitudes toward them, the teaching practices of peer instruction and group work appear common.

Lastly, a final example of how a failure in group work was utilized by an instructor in a uniquely military way. This illustration serves as a transition to show how instructors can use the teaching of science to prepare their students to be officers using lesson material that has no connection to science. The following excerpt is an instructor's recalled dialogue between themselves and a student encountering difficulties working in a group.

> *"[after] they get into these lab groups, that's their group for the semester. And I had a student complain about their group and say: 'Ma'am, they're just not helping me'. I said: 'Well, did you cooperate with them?' They would reply: 'I just know, they won't help me, I need help from you'. I said: 'well, you have a group, your whole group needs to be here'. And the student replied: 'no, they don't do anything.' I said: 'Lieutenant, your platoon isn't working with you. How are you going to get them to work with you?' And they're just flabbergasted and say: 'but this is my grade!', and I'm like: 'That's your platoon! That's your mission! You have to overcome it!'" – US Army, active-duty military instructor*

There are a number of interesting observations to extract from this recounted exchange between instructor and student. It begins with the common scenario of a student having difficultly working with their laboratory group. The student requestions assistance from their instructor but the instructor directs them back to first seek help from their group. When the student shows continued resistance to working with their group the instructor changes the object of the lesson. The student's

personal concern for their grade is met by a reframing of perspective by the instructor. The instructor calls the cadet by their future officer rank of lieutenant and the lab group is recast as their platoon. The instructor reframes the lab assignment as a mission and the student is sent back to overcome these obstacles. The instructor directs the student to reprioritizing group functionality over individual success in the form of a grade. In addition to learning science, this cadet must also learn how to work on a team. A question about science matures into an opportunity to prepare officers.

This instructor seized on an unprompted opportunity to transform a question about science into a lesson that would prepare a future officer for military service. This activity might not be considered a science teaching practices but it could be considered a military focused teaching practice. This account was not singular, other instructors reported acting on similar opportunities to teach lessons that had minimal to no connection to their science. This teaching practice and an associated beliefs about the value of non-science content is explored in the next section.

4.2.4 **Instructor teaching practices not related to science content**

Section 4.1 presented the idea of mission and that many of the findings to the research questions could be explained with a central belief in of preparing officers for military service. This section continues the exploration of teachers' beliefs and practices by examining the accounts of non-scientific content being incorporated into the classroom as part of officer development. Non-scientific content will be defined as topics that has minimal to zero connection to the sciences of physics, chemistry, or biology and generally could be described as character and leadership development. Evidence will be presented that weaving non-scientific content into the science classroom was an accepted practice in the guiding documents, by the department leaders, and by many of the instructors themselves. This section will also present findings on what topics science instructor chose to address.

It was found that the guiding documents gave instructors the freedom to present more than simply content from their academic subject. An example from the US Air Forces Faculty hand book is as follows:

> *Character and leadership development is the common thread through all learning experiences in the Course of Instruction. As such, all faculty and staff members, regardless of whether they are teaching academic courses, leading military training activities, or coaching cadets on the Academy's athletic fields are expected to promote a climate of moral growth, honor, and positive*

> *human relations. This is done through explicit classroom instruction, discussions with cadets (both in and outside the classroom), and impeccable role modelling of what it means to serve as a leader of character, dedicated to service to the nation. (United States Air Force Academy, 2019, pp. 38–39)*

Similar statements were found within both the Army and Navy faculty handbooks (United States Military Academy, 2014, pp. 3, 10) (United States Naval Academy, 2015, pp. 3, 21, 74). This passage expresses that all instructors and faculty, regardless of job, are responsible for character development and that is could be caried out in several ways. The actions of the Army instructor in the previous section who dealt with a student struggling with their lab group appear to be a textbook example of this type of guidance in use.

Support for this practice was also found with some of the department leaders. One department leader had very strong views on the practice and their account is presented below.

> *"I require my instructors to talk about a SHARP [Sexual Harassment/Assault Response and Prevention] topic. Just have that engagement with the cadets. And here you are sitting in the classroom, having a conversation on something other than physics. Our faculty are very quick to talk about their experiences in the Army. And I require it, because they're developing leaders of character. And so, they do that a lot. In fact, sometimes they'll take an entire lesson and just talk about something in the Army. Cadets know they're responsible for the [academic] material" – US Army, active-duty military instructor and department leader*

Several findings can be extracted from this passage. This department leader required the instructors working within their department to talk about a specific sexual harassment and assault prevention program with their students in the classroom. But the department leader later expanded the non-science topics to include instructors' experiences within the Army. The department leader also shared their belief that their instructors were also eager to talk about their experiences. These practices were also not simply recommendations of the department leader, twice in the account they mention that these practices were required of instructors. This is another confirmation for the finding that department leaders influence the practices in their departments. Furthermore, this department leader expresses the belief that sometimes it is acceptable for a science instructor to use an entire lesson for a non-science topic. The department leader did not appear concerned about students missing out on the regular lesson. This appeared to be justified by a belief that cadets knew they were responsible for the course material regardless of the instructor did in class.

It should be noted that this position represented one of the strongest in support of non-science content or active character development in the classroom. While this example is useful for describing the practice, other department leaders held less enthusiastic views of the practice. department leaders and instructors at other schools had different views, some indicated it was acceptable to present character development in the classroom but that much more consideration should be given to focusing on the scientific content. This was one of the beliefs and practices that was not as uniformly reported by different groups. The third research question was directed at exploring how beliefs and practices varied between different military settings and this topic is presented with other findings in chapter 6.

Beliefs and practices about character and leadership development have been presented based on data from the guiding documents and department leaders. The next section will examine similar data from the instructors themselves, it will also present data on the range of specific topics deemed to be relevant to developing officers.

Examples of non-science related content presented by teachers

The guiding documents listed that character and leadership development might occur three ways through explicit classroom instruction, discussion, and role modelling. Explicit instruction was interpreted as practices that instructor prepared in advance. Some instructors reported using a routine for the practice of developing character and leadership development. A few instructors reported using the first few minutes at the start of class to address a non-science topic prior to moving into the science lesson. Another reported routine was instructors saving some class time at the end of the week for discussion of non-science topics. Instructors referred to these explicit discussion times as "war story Fridays" or "fleet Fridays". Instructors' using these times for the retelling of personal experiences within the military often involving deployed or combat experiences, but many also presented other life lessons learned during their time in military service. Instructors reported that these discussions were popular among cadets. These practices could be considered both explicit instruction on character and leadership but also role modeling as the lesson often included personal experiences of the instructor. The following is one instructor's account.

> *"A lot of these kids are young and they still just don't understand a lot of things. A lot of these guys think war is cool. And they can't wait to deploy. And I always have to tell them, 'I used*

to think the same way as you, just be fortunate if you don't have to deploy, or pray you won't have to deploy because it's not everything is cracked up to be" – US Army, civil servant instructor

This instructor provided an alternate view to war story Friday, they held a view that their students thought war was cool, and that they could not wait to get into combat. This instructor provides a more sobering belief that their views of war have changed and that war is not everything it's cracked up to be. He encourages them to be thankful, and even hope, that they never get deployed to a combat zone. Through this account we see that a science instructor is attempting to correct a student misconception that is not about science, but actually about the nature of their profession.

Instruction through discussion was interpreted as unplanned discussion on character and leadership development and engaging in them when an opportunity presented itself. During the interviews instructors used phrases such as "it was a perfect teaching moment" to describe how they identified these opportunities. Role modeling was interpreted as a continuous process of instructors conducting themselves in a way that aligned with institution outcomes. Data suggested that role modeling typically also include explicit instruction or discussion when instructors shared their own personal experiences with their students. The following data are accounts of instructors providing non-scientific content in their classes. Data from some interviews also presented additional findings for why instructors spent time on developing their students in non-scientific ways.

"We have a responsibility to train that next generation, to get [them] ready for when they're in charge." – US Army, active-duty military instructor

This account suggests a belief that instructors see themselves as training the next generation and take their teaching serious. This concept of training the next generation was reported across a number of instructor interviews because their students would become future co-workers as each school requires 100% of their graduates to serve in the military after their education it is not unlikely that students are not only future replacements but possibly even current co-workers. One instructor reported the following discussion among instructors.

"I hear people talking about, 'well, this [student] won't do this, I'm not so sure I want them to be an officer in the Air Force'. They are thinking what's this person going to be like when they leave here?" – US Air Force, civil-servant instructor

This instructor reported how a student's behavior prompted a discussion between instructors on that student's fitness for military service in the future.

The section next section will present specific examples of the types of non-scientific content that was reported in the classroom. The guiding document presented mentioned character and leadership development and mentioned the topics of moral growth, honor, and positive human relations. Specific uses of these will be presented below. In addition to these topics instructors also presented material that would be useful in preparing for a career in military service and even life skills useful to all citizens. The first topic presented will concern moral growth and honor.

Moral growth and topics on ethics

As foundational to the profession of arms, discussions on living a moral life and doing the right thing were reported. Instructors brought elements discussing moral growth and ethics into the classroom on several other topics as presented below in Table 16. The following tables have been developed from interview data but are in summary form.

Table 16: Examples of topics involving moral growth or ethics discussed by instructors in the classroom

Discussion Topic(s)	Examples reported by instructor
Discussing current or old policies	Through its history, the US military has had changing policy on sensitive topics such as race, gender, and sexual orientation. Instructors reported discussing how policy changes happen regularly and how to work through new definitions of right or wrong withing the military.
Ongoing court martial boards, scandals, or other disciplinary actions	Court martials are trials in the military legal system. Instructors reported discussing the rulings of recent court martial boards with cadets. Instructors also mentioned discussing disciplinary actions of less serious offences and even rumors of scandals circulating in the student body. These discussions often involved providing perspective of how military law and order works in the operational environment.
military situations involving ethical consequences	Instructors reported discussing how ethical dilemmas could be encountered during military service. one ethical dilemma presented involved how to mentally process causing undesired civilian casualties during military action. One instructor specifically mentioned teaching about a hostage situation at the embassy they had encountered.
Failure within the military	Instructors reported discussing with their students what it's like to personally fail in a culture that is obsessed with winning
Examples of good and bad leadership	Instructors reported accounts of discussing individuals who they deemed good or bad leaders and the qualities that made them so.

In the presented table, instructors sourced topics and material from both current events, such as policy change or recent court marital as well as from their personal history. These topics often forced cadets to consider the ethical nature of their service in the armed forces. Instructors reported

using these scenarios as teaching aids to help students learn how to make more ethical choices in the future. In addition to ethics, science instructors also mentioned topics involving positive human relations.

Positive human relations

Some instructors reported having discussions on positive human relations with their students. While some of the topics presented would be valuable to any student, many of the human relations topics presented by these science instructors were tailored towards human relations encountered during a life in military service. These topics often catered to young adults interested in relationships and family but having to navigate the constraints of a military career. Many of these constraints were forced upon military personnel since military service is often a very mobile life. Officers can expect to move to a new location every 2-3 years as they receive new assignments. Training and deployments can even shorten that move cycle during various times in a career. Table 17 includes serval summaries of discussions about human relations that instructors reported having with their students.

Table 17: Examples of non-scientific positive human relations instruction

Example reported by instructor	Discussion
Being a good “wingman”	Reported within the Air Force was the wingman concept, an aviation concept where military aircraft support each other and stick together. Air Force instructors adapted this concept to support friends and co-workers particularly in times of high stress or loss.
Value everybody's background	Military members often serve overseas where social norms might be very different. Instructors reported a need to understand and value everyone’s backgrounds and respect those differences.
Relationship advice during a military career	Some instructors reported sharing the difficulties encountered with dating while in the military. Instructors reported discussing long distance relationships and the difficulties in dating other military members assigned to different locations.
When to get married within the military	One instructor discussed timing issues on when are convenient times to get married during a military career. They also reported presenting on the types of support provided to military spouses. In addition to this several instructors reported on the support provided to military to military marriages
Family planning during a military career.	Some instructors reported sharing personal accounts of the difficulties of family planning while in the military. Assignments like deployments to combat locations overseas could require spouses to be separated for up to 9 months at a time.
Sharing of personal stories of loss within relationships	Instructors reported sharing personal stories of loss and how they struggled through. One instructor in particular reported sharing a very personal account of loss involving a miscarriage of a child. The same instructor reported that they received feedback several years after one of their students had graduated. The student contacted the instructor to let them know that they too had suffered a miscarriage and the discussion in the classroom had greatly helped the student as they worked through their loss.
Parenting as a military Member	Several instructors reported teaching on the many likely difficulties in regards to parenting within the military. Some of the difficulties included shifting roles during overseas deployments and helping children with losing friends during moves.

Career and general life skills

Lastly, as opposed to issues of ethics and positive human relations, instructors chose to discuss basic skills or information that would be useful or necessary of officers during military service. Some were specifically in connection to a military career while some were general life advice and examples from collected data can be seen in Table 18.

Table 18: Examples of topics involving life skills in the military

Examples reported by instructor	**Description**
Personal Finance	Numerous instructors reported presenting lessons on personal finance. Topics included budgeting, investing and saving for retirement after the military.
Home ownership as a military member	Instructors discussed the military considerations to take when considering when and how to buy a house.
How to use productivity software	Instructors reported teaching lesson on how to use software such as Microsoft Office. In addition, instructors presented lessons on the soft skills that would be needed of officers in their future work environments. Most military professions still require use of technology and training in the norms of email and scheduling.
Pet ownership	Instructors reported giving advice on how to own pets when there is the possibility you might deploy overseas for months at a time.
Military skills (not involving combat)	Some instructors reported teaching on how to accomplish various activities in the military that didn't involve combat. Examples of these included how to request and take personal leave or how to move house within the military. One instructor referred to these as "life hacks"
Differences between military service in the academic environment and the operational environment	A constant theme reported by instructors was how they were trying to prepare their students for a change in mindset from an education environment to an operational environment within the military.
Graduate education	Instructors reported giving advice on the peculiarities and opportunities to pursue higher education within the military. Topics included how to utilize tuition assistance other considerations of higher education and its connection to promotion.

It appeared that instructors wanted their students to be successful in aspects more than just the science content of their classroom. Some instructors believed that some of these lessons weren't going to be intentionally taught anywhere else so they felt a compulsion to ensure these future officers were prepared for military service. This section has presented some of examples of the types of non-scientific content provided in the classroom. The next section will present some of the reported usage data collected in the survey.

Reported beliefs about and usage of non-science teaching practices.

Interview findings about these non-science practices were included in the survey. Figure 23 presents instructor data on if instructors agreed with the belief that teaching non-science related content was part of being a good instructor at a US military service academy.

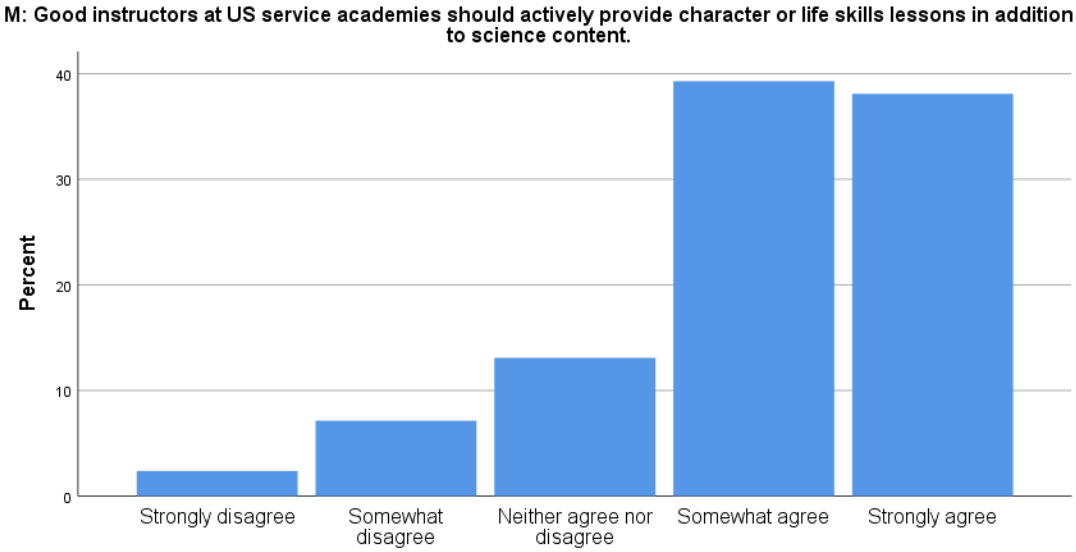


Figure 23: Beliefs about the desirability of providing non-science content such as life-skill and character lesson (N=84)

Almost 80% of instructors across all three schools agreed or somewhat agreed that good instructors should provide character development or other content in addition to science content in their classrooms. These data suggest that a many of instructors hold beliefs in alignment with the guiding documents and department leaders but at differing conviction levels. But the research questions also sought to investigate the reported practices in addition to beliefs so additional survey questions were developed to see how these beliefs translated into practices. Instructors were asked to report their use of both utilizing opportunities for character development and preparing non-scientific content. Two questions related to practice were developed to measure instructors' discussion of character development, first with preparing material ahead of time Figure 24 and second buy utilizing unplanned opportunities in the classroom.

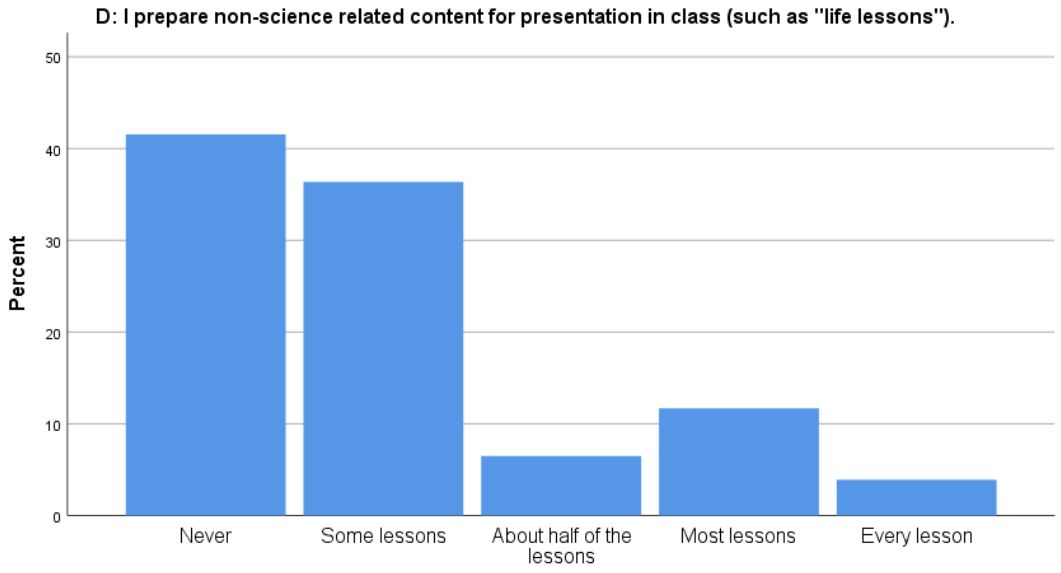


Figure 24: Reported occurrences of non-science content such as life-skill in the classroom (N=77)

Survey data indicated that 40% of instructors made no efforts to actively prepare non-science material for class. 35% of instructors reported the practice on some lessons. Approximately 25% of instructors reported the practice on half or more of their lessons. When asked if instructors utilized unplanned opportunities Table 19, more instructors indicated using the practice.

Table 19: Reported instructor practices of utilize unplanned opportunities to discuss character development

	Never	Some lessons	About half of the lessons	Most lessons	Every lesson
P5: I utilize opportunities to discuss character development if they present themselves in class.	6.3%	55.8%	9.5%	13.7%	14.7%

When asked about utilizing unplanned opportunities to discuss non-science topics such as character development, only 6% of instructors indicated never taking part in the practice. Data comparing beliefs about the practice and use of the practice appeared to support an inconsistency claim between beliefs and practices (Kagan, 1992). Possible reasons for this disconnect could be attributed to time restraints or other resource limitations. Most instructors might discuss character development topics if they present themselves but it appears fewer have the time to do so or are unwilling to put the extra effort into preparing and planning those discussions. The survey also

included a free response item asking what resource would enable them to become a better instructor and the most frequently mentioned resource was time.

These sections have presented how preparing officers with character development content was identified in the guiding documents, the department leaders and the instructors themselves. The findings on this topic will be further presented in how the instructors perform this practice.

4.3 Chapter summary

In summary, chapter 4 presented findings that make meaningful contributions towards answering the first two research questions involving identify teacher beliefs and practices, and identifying the influences on those beliefs and practices.

Section 4.1 developed the finding that one central and possibly unique belief was instructors' beliefs about the aims of science education (Bryan, 2012; Fives & Buehl, 2012; Pajares, 1992). It was presented that most instructors held the belief that the aim of science education at the US military service academies to develop leaders of character for future military service. Documents and department leader evidence was also presented that this belief was likely influenced by it being the mission of each institution and supported by the leaders of each science department. Section 4.1 also proposed the finding that this belief about mission would serve as a guiding belief (Rokeach, 1968) towards understanding other beliefs and practices.

Section 4.1 presented evidence for a variety of beliefs about education and teaching practices that were held by science instructors. Evidence was presented that US miliary service academies held the general beliefs about student learning that it occurred when the students were engaged. Practices to increase engagement included using teaching practices where military applications of science were used to adapted the scientific content to students in the US military. Practices in increase student engagement also included question asking during lecture and in-depth question asking during board work sessions. Finally, evidence was presented that instructors held the belief that science teaching should include non-science or character developmental topics that would prepare their students for service in the US military.

Due to the gap in knowledge on beliefs and practices of military instructors, these findings have the potential to make significant contributions to knowledge. The next chapter will present findings that more fully explore how military culture might influence the beliefs and practices of military instructors.

5 FINDINGS 2: TEACHING SCIENCE AS A MILITARY OPERATION

Introduction to the chapter

Chapter 4 presented a number of findings the educational beliefs and practices of science instructors as the US military service academies. This chapter presents findings as evidence for the research question seeking to explore any influences on the beliefs and practices of science teachers at the US military service academies. Central to this chapter is the idea that an individual's current beliefs have been meaningfully influenced by previous experiences (Fives & Buehl, 2012), if the current beliefs of instructor are to be understood, the previous experiences within the US military should be explored. In general, this chapter seeks do develop a claim that science teachers at the service academies organize themselves and conduct their science teaching in a similar fashion as to how traditional a military unit would be organized and operated. Section 5.1 presents evidence for how teachers are selected and trained for teaching. Section 5.2 presents evidence for how military members are generally exposed to hierarchy, standardization, and camaraderie while in military service.

5.1 Selection and training of US military science instructors

This section presents the evidence on the practices and contextual influences in respect to the selection and training of science teachers at the US military service academies. It introduces the claim that the selection of instructors, especially military instructors, resembles the practices assignment selection across the military. Section 5.1.2 presents the data on teacher training and presents the claim that teacher training at the US service academies follows similar practices of training to what might be expected in the combat focused areas of the US military.

5.1.1 Instructor selection

As discussed in section 2.1.3, science instructors consisted of both active-duty military and civil servants. This section presents the evidence for the various practices associated with the selection of both active-duty military and hiring of civil servants as instructors at the service academies. Different processes were reported in their section or hiring and a discussion of military selection will be presented first followed by a discussion of the hiring of civil servants.

Selection of military officers as science instructors

This section presents and discusses the data on how military officers were selected for their positions as instructors teaching science. This data is used to suggest answers for the research questions focused on how the context of the military influences the practices of instructors. One of the claims of this section as suggested by the data is that teaching of science was never the focus of a military officer's career but rather and ancillary duty in the development of a military officers' primary occupation. Correspondingly, the selection process for instructors and associated practices are more similar to traditional military assignments and practices in that military officer careers seemed to be largely controlled by centralized personnel organizations within each service. Suggested effects of this centralized control include how military officers often have limited freedom of choice, are often selected for instructional positions prior to being qualified for them, and career timing has significant impact on when or if an officer might ever the opportunity to instruct science. The conclusion of this section will present a discussion on how the hiring of military might influence the beliefs and practices of military science teachers.

When the US military service academies select instructors to teach science, they are selecting their instructors from among an existing a pool of pilots, infantry officers, and other military occupations. When the military instructors were asked in the survey to respond to the question of "What is your primary occupation within the military" not a single response included "teacher" or "instructor." Responses on the survey included the following occupations: pilot, naval surface warfare officer, intelligence officer, infantry officer, surgeon, acquisitions officer as well as others. These responses could suggest that military instructors hold the belief that they are an officer first, and then an instructor of science. This was supported by additional data on military officer careers from the interviews. When discussing career history, it was reported that teaching science was often only a career broadening activity that could compose approximately 15% of an officer's total service in the course of their military career. When an active-duty science instructor was thinking about their career, they often had much more experience in fields other than teaching. These careers were filled with a number of other assignments that seemed to be purposeful in the development of officers.

Data from the interviews, as well as the author's personal knowledge of the military, indicated that these careers are carefully and actively managed by centralized personnel management organizations within each service. With approximately 2.2 million activity duty military service members, these personnel organizations within each branch of service were tasked with developing a variety of personnel with the appropriate education, training, and experiences necessary for them to function a variety of functions with in the military roles. This centralized process influenced the selection of science instructors and led to some interesting observations. Three aspects of this control will be covered below and include the lack of freedom for potential instructors, selection based on future potential not current qualification, and the effect of officer career timelines.

The first observation made involved instructors' possible lack of freedom to choose instructional duties. The data showed that the selection of an officer to become a teacher did not lie with either the potential instructor or even the academic institution but with the centralized personnel organization. Here is the idea illustrated in the following quote.

> *"I always thought it'd be fun to come back to this department. Pilot shortages at the time in the late 90s, early 2000s prevented me from getting released by AFPC. I tried a couple times unsuccessfully. But finally, in 2008 [I] got released at the same time that the department here had a slot to sponsor me so they sponsored me for a Masters [degree] at AFIT." – US Air Force, active-duty military instructor*

This instructor was a career pilot and described some of the circumstances surrounding their selection as a science instructor. They identified the centralized organization for the US Air Force, the Air Force Personnel Center (AFPC), as the one who controlled their opportunities to teach (AFPC, 2017). This is the organization that manages the development and movement of approximately 330,000 US Air Force active-duty military members. The instructor reported requesting permission, referred to as "getting released" from AFPC in order to pursue their interest in teaching. The instructor reported being unsuccessful over a number of years in obtaining permission from this organization due to reported pilot shortage within the flying community at the time. The quote seems to suggest that the centralized organizations did control the officer's career but the account does indicate that there was some mechanism for members to express their personal preferences. It is possible that better candidates existed and those who may have most wanted to teach never had the opportunity due to not being "released" from their career field. While some instructors were

successful at times in getting desired assignment to teach, others were not. In the US Air Force, the euphemism for getting an assignment not based on personal preference was known as "needs of the Air Force". This ceding of personal freedom to decide on their career trajectory and to be instructors was not isolated to the Air Force but was identified in other services as well and reported during the interviews. During a discussion on their career history, an army officer talked about how they were placed into their specific career field against their wishes.

> *"You get selected as Needs of the Army. So, I was Needs of the Army, so ordnance corps" [as an assignment] – US Army, civil servant instructor*

This officer used the term "needs of the Army" as an explanation of how they were assigned to be an ordnance officer. This lack of freedom was not even limited to one specific assignment, this officer's career assignment was based on the "needs of Army/Navy/Air Force". Military service offers a lot of opportunities but is still grounded in the fact that it is still a service. Data from the instructors indicated that they were able to express their personal desires to their centralized organizations but ultimately the freedom to instruct was not up to them.

The finding of military members being selected to instruct involved how selection for teaching seemed to rely on the *potential* abilities versus qualifications already in hand. This idea was previously illustrated in the quotation from the pilot above, "so they sponsored me for a masters [degree] at AFIT". A minimum of a master's degree was required to teach at any of the service academies and the instructors selected to teach typically did not possess it at the time of selection. In this case the US Air Force has its own graduate school known as the Air Force Institute of Technology (AFIT). This pilot was selected to teach *prior* to holding the necessary academic qualifications necessary for the teaching position. Most active-duty military instructors, as the one mentioned above, were sent to graduate school for a science degree in the specialty *after* they had been selected for the job. The same practice was held by the department leaders as well. During an interview, a department leader described the processes and their role in selecting future instructors.

> *"I'm good at selecting faculty, that's the best skill I have. I know who to select for grad school and to have come back and teach. And so, I bring in good examples of what right looks like, they're my faculty here." – US Army, active-duty military instructor and department leader*

This leader stated how they selected faculty, *then* sent them to grad school to obtain the qualifications need to return and teach. They reported selecting for "rightness" presumably what an ideal officer would look like in the estimations of this department leader. The common observation among military instructors was that they were selected based on some potential, and then sent to training to fulfil the position. Based on personal experience this practice of selection for positions is a common practice with most positions within the military. The practice is even identified specifically in the criteria used to identify members for promotion with the military. As expressed in Air Force Instruction 36-2406 promotion is based not on currently being qualified for those duties but on "the *potential* to serve at the next higher grade" (emphasis added) (Secretary of the Air Force, 2021, p. 122).

This process of selecting instructors prior to graduate school led to some unexpected motivations expressed by a few of the instructors. One instructor prioritized the opportunity for graduate school over the actual instructional assignment. When asked in the interviews "what led you to want to become a teacher?" this instructor reported:

> *"[The] opportunity to go to graduate school. I didn't know anything about teaching whether it was going to be fun or traumatic or what, but it was an opportunity to get a graduate degree. And at the time, it really fit my timeline" – US Army, active-duty military instructor*

This instructor's stated desire to teach was actually based on the opportunity to obtain a graduate degree with the military. It seems possible that to them the true prize was the education provided in preparation for the teaching assignment, not the assignment they were being prepared for. It is possible that other officers who had no interest in teaching might have applied for teaching positions simply to access opportunities for graduate education during their military career. The last point to mention was this instructor's reference to a teaching assignment that "really fit my timeline". The last section on selection of military members as instructors will address how career timing was a significant influencer on when or if an officer might become a potential science instructor.

The last observation involved career timing. The selection of military to teach was typically a process that lasted several years and had to be coordinated with specific times in an officer's career development. In an explanation of this practice from a department leader the following description was collected.

I have to plan out, [at] least a minimum for a PhD, five years, okay. For rotating faculty, we're going to send them off to school, get the master's degree which take, which would give them two years. And they don't have to do that year long, OE experience so two years, then you got to get a year for the selection process, I'm already looking at four years out, to start getting those faculty and the PhDs just five, six years out. So, we're way ahead of where we need to be in terms of thinking the future, you know, four to five years out" – US Army, active-duty military instructor and department leader

From this department leader's description of their timing, they refer to planning for instructors "way ahead" of when they will be required to be in place to instruct. According to the department leader's account, for an instructor to move out of their primary career field and "rotate" into a teaching position for an assignment it is an approximately 3-year process. They describe 1 year in selecting the future instructors followed by 2 years to obtain the master's degree required to teach. To obtain military instructors with a PhD this timeline was further lengthened to 5-6 years. In addition to the 1-year selection process, military officers were typically given 3 years to complete their PhD and then required to return to their primary career field between their education and their instructional assignment. The reported process involved between 3-7 years for the development of military instructors and similar timelines were reported at all service academies.

Some department leaders termed it a "pipeline" where they were constantly selecting new instructors every year so that there was always a flow of new instructors in the future. This was expressed by a different department leader.

"Ultimately, I see it as my job to create the pipeline of talent to replace everybody that's here." – US Army, active-duty military instructor and department leader

This excerpt came from a larger discussion on how this particular department leader shaped their department and ensuring there was a constant flow of talent was one of their primary responsibilities. In addition to require extended time frames, from the instructors' career standpoint it was also reported that the window of opportunity to pursue science teaching was not perpetually open during an officer's career. As mentioned previously, the centralized personnel organizations controlled when instructors were allowed to apply for such assignments. This was illustrated by a previous quote where a pilot mentioned "[I] got released at the same time that the department here had a slot to sponsor me". In an additional example from the US Navy, a submarine officer described their

assignments as a rotation between assignments at sea (in their case under the sea) followed by "shore duty" assignments. This officer was only eligible to instruct during their shore duty.

> *"I was just looking at the kind of the career progression, regardless of what I did. If I wanted to go back to a submarine and do the submarine thing, I was going to be able to do that, regardless of what job I chose for my shore duty" – US Navy, active-duty military instructor*

So, for this instructor, the opportunity to possibly teach only occurred every other assignment when they were completing a shore duty as it would not take them away from their primary career field and would have less impact on their overall career progression. This was also reported from instructors within the US Army.

> *"[the Army] contacted me and asked me if I was interested [in teaching] but I'd just took company command... in the Army, when you get company command, that's like a big deal. So, I was like 'No', I'm not giving up command to go teach" – US Army, civil servant instructor*

In this officer's situation, they delayed acting on a previous opportunity to become an instructor because they believed their current assignment of "company command" was "a big deal". This instructor was conscious of the possible career effects that taking an instructional assignment at that current time.

In summary, the data presented on the selection of active-duty military to be science instructors suggests some answers for research questions investigating the contextual influences on instructor practices and their beliefs. While this contextual discussion was not directly tied to an exact practice in the classroom the situations around how they were could provide understanding on what the instructors believe and practice. The central claim that teaching science was never the central focus, but rather a developmental opportunity in a military officers' career, was illustrated. This section also presents the data to support the claim that the beliefs and practices surrounding the hiring processes are in support of the central theme and similar to generic hiring processes across the military. Future military science instructors were selected from a pool of military officers and the process was shown as managed by a centralized personnel organization. This centralized process led to aspects of reduced personal freedom in the ability of officers to teach. It also led to the practice common in the military where selection for opportunities often happened prior to qualification for them and that it could take up to six years of preparation to develop the appropriate education and experience needed for instructors. Understanding how the selection process works will be insightful in

understanding some of the other practices that the instructors employ in the classroom below. Just as their selection looked very similar to regular military selections, so their teaching practices incorporate some regular military practices. But prior to examining those practices, a discussion of how the civil servant instructors were selected as science instructors will be presented.

Selection and hiring civil servants as science instructors

The next section examines the data on how civil servant instructors were hired and discusses the similarities and differences to the active-duty military data presented above. The data in the section continue to answer the research questions seeking to identify the contextual influences of a military service academy on science instructors. This section will follow a similar topic order to the discussion on active-duty instructors and will cover data on personal choice, qualifications for selection, and timing issues. The central claim being put forward throughout this section is that the process for selecting and hiring civil servants looks more similar to what might be encountered in a non-military academic institution than it did for the active-duty military instructors.

When examining the data on how civil servant instructors were hired, no centralized organization could be identified from any account. Three sample accounts are presented below.

> *Account 1: "[I] went off to graduate school, and did computational quantum chemistry and electronic structure for the next five years and graduated in 2010. [I began] looking for jobs in the spring semester of 2010, came across the listing for an assistant professor of physics at [my institution], …, [I] applied, got a phone interview, and then a phone call saying I got the job. And I've been here ever since." – US Army, civil servant instructor*

> *Account 2: "I was at [a university on the east coast of the US], and [my husband] was at the Pentagon, I was driving home on the weekends, which didn't really work for either one of us. And so, he gave up a command position and applied here, he got the job, and then I applied here, and I got the job. … So, I always say, I came for my husband, but I stayed for the cadets." – US Air Force, civil-servant instructor*

> *Account 3: "I went to graduate school at [a university in the Midwest of the United States] … I had a good colleague who came here directly after grad school. And I went to do soft money research looking for near Earth asteroids at [a university on the west coast]. I stayed there for seven years. And in the process, [the colleague] started contacting me for research projects for students. And so, I worked with three midshipmen remotely. And at that point, she said, 'everybody's kind of familiar with what you're doing, we have a position coming up, you should apply'. And so I did" – US Navy, civil-servant instructor*

In each of these three accounts, the instructors describe their circumstances prior to them applying for a teaching position. In the first case, the instructor simply was searching for a job after completing graduate school. In the second example the instructor was searching for a different

teaching job in order to be geographically co-located with their spouse. In the last account, the instructor moved from a research position at one university to a teaching position based on some academic social connections. Unlike the active-duty military instructors, none of these accounts report control by a centralized personnel organization. No civil servant instructor in any account reported any obligation to a service academy or the US military in general prior to their selection. They were not part of any career field that was being actively managed by a centralized personnel office within the military. These instructors reported applying directly to the teaching department's employment postings. It could be argued, that unlike the active-duty military instructors, these civil servant instructors had a higher degree of personal choice in their pursuit of teaching positions at these same schools. But the data does not suggest that these instructors were without influence. The first account included motivations of efforts to simply find employment after graduate education. The second account included stated motivations to be co-located with a spouse. The last account included some possible motivations of moving to work with a college and transition from a less stable funding source to a more stable teaching income. The military was never a direct influence on any account, or at least not in the same way as with active-duty instructors. It should be noted that in the second account military influence could have been applied indirectly through the instructor's spouse, who was indeed active-duty military. In this instance, the marriage to a military member drove some job locations for the military member which required some career negotiations between spouses in order to have collocated professions. The active-duty spouse would be subject to the same kind of management described in the previous military instructor section. While not a focus of this paper, from the authors personal experience it can be stated that often immediate family members of military members surrender some of their personal choice as they move with their active-duty family member across assignment locations.

Another difference from the active-duty military accounts, there is no indication that these individuals viewed themselves as a member of a different career field taking a career broadening assignment into teaching. Two individuals were already at universities and one was seeking initial employment after university. Unlike the military, these were academics already involved in teaching or research.

In another comparison to active-duty military instructors, these civil servant instructors were selected having already completed the necessary academic qualifications to teach. Consistent with the three accounts above, no civil servant instructor reported being selected to teach prior to attending graduate school. They were not hired based on potential ability but with proven academic accomplishment and in some cases more prior teaching experience.

Data from the survey revealed that 98% (53 of 54) civil servant instructors reported holding a PhD or terminal degree in their field of study. When compared to the active-duty military instructors of which only 38% (22 of 58) held a PhD, the civil servants were hired with a higher level of academic qualification than the military would hold even after being sent to graduate school. This disparity in academic qualification could have several reasons. The first suggested reason from the data for the higher percentage of PhDs among civil servant could be a type of division of labor among the departments. With a mix of both military and civil servant instructors, each would be able to provide a different blend of expertise and experience in the classroom based on their backgrounds. Military officers would be able to augment their teaching with experiences from their active-duty military career while civil servants might possess a much richer and deeper expertise in their particular academic field. The following excerpt by one department leader suggests this idea of division of labor.

> *"So, all of our civilian [civil servant] faculty that we have here are experts in their in their science. And they come in here with the ability to conduct research…Whereas the military faculty might have more of a focus on the teaching, of course everybody's got to focus on teaching, but they [the military] also got a focus on that cadet development piece, the military development piece," – US Army, active-duty military instructor and department leader*

This leader noted the natural differences in backgrounds between instructors and how they might focus on different elements of officer development. If developing officers is the central focus of these academic institutions, as presented in section 4.1, then using both active-duty military officers and civil-servants in combination seems a plausible approach to developing both the academic and military qualities within students. The leader noted that this division of labor wasn't absolute, in that both types of instructors needed to focus on the teaching element.

Just as the active-duty instructors did possess some high levels of academic expertise, they did not possess them in the same degree as the civil servants. In a reciprocal way 8 of the 54 civil

servant instructors indicated in the survey indicated that they had prior active-duty military service experience. So, in reality some civil servant instructors were able to share their military experiences with cadets and some military instructors possessed more than typical academic qualifications, such as a PhD in their scientific field.

Another possible reason for the higher academic qualifications maintained by the civil servant instructors could be due to the requirement for the institutions to maintain their academic accreditation. As discussed by Cayetano (2015, p. 12) in a study on the accreditation of the US military service academies, these schools are accredited by both the Middle States Commission on Higher Education and the North Central Association of Higher Learning Commission. These accreditation commissions require academic departments to hold a minimum of percentage of faculty with terminal degrees in their fields. Hiring civil servants with PhDs might ease manning processes in the department. If more civil servants hold terminal degrees, it reduces the requirements on the active-duty military instructors to obtain this level of preparation. As discussed in the previous section there are long timelines involved with preparing military to teach.

In terms of being selected with prior teaching experience, from the survey 30% of civil servants (16/54) had prior teaching experience compared to 20% (12 of 58) of active-duty military instructors. While there were minimal differences in whether they had experience, the amount of prior teaching experience in the civilian group was much larger. The quantitative aspects of this topic will be more thoroughly discussed in the next chapter on difference between groups.

The last significant difference noted in the data was that for the most part the civilian servant were academics only, and never part of a different career field. No civil servants indicated they were never going to "rotate" back into a different career field after a few years of teaching. While military instructors only were allowed to teach at select times in their careers, this was not the case for civil servants and they did not need to manage similar elements of career timing. This resulted in the amount of teaching experience held by civil servants being much greater, as will also be discussed in the quantitative chapter.

In summary, civil servant instructors were selected to teach at the US military service academies with different criteria and career circumstances from their active-duty military instructor

counterparts. They were free to apply without being managed by a centralized personnel office. They almost always were permanent members of an academic community and did not consider themselves members of a different profession. They were selected with a higher level of academic qualification than the active-duty military instructors. As initially suggested, although no civilian schools were included in this study, it is likely that the hiring of these civil-servant instructors would look very similar to the what might happen in a non-military college. With the discussion of how teachers were selected for their positions concluded, the next section presents the data on teacher education and training at the US military service academies.

5.1.2 Teacher education at US military service academies

This section presents the different types of teacher education and training that was provided to almost all new and in-service science instructors at the US military service academies. The discussion will examine both the formal education programs such as the new instructor training programs and in-service teacher programs as well as how some teacher training practices might have been carried over from training and education within the military.

Formal teacher education and training

Understand the teacher education programs is useful towards understand the beliefs and practices of the instructors. The teacher education program at the Army's service academy was the focus of a different study(West, 2011) so an in depth description does exist on their program. This section will give a higher-level description of the teacher education programs in efforts to answer the research questions on understanding contextual influences. Data on the descriptions of new instructor orientation programs were collected from documents and instructor interviews. Data on the science instructor's participation in them was collected during the interviews and in the survey.

In general, post-secondary education institutions in the US do not require certifications in teaching for their instructors and instead rely on academic qualifications in the form of advanced degrees (Labaree, 2018). Accordingly, there are no externally levied requirements for teacher education at the US military service academies. Regardless of a requirement, each military school created their own teacher education and training programs which all new instructors were required to

complete (United States Air Force Academy, 2019; United States Military Academy, 2014; United States Naval Academy, 2015). The names of these programs varied somewhat and included terms such as: new faculty, new instructor, training, development, orientation, etc. so some variation of program name may be referenced in this section. These programs of instruction were fairly similar in nature across the three institutions examined but descriptions and differences were noted. Discussions on service distinctions are presented but not fully emphasized in this section. Service differences is the topic of Chapter 6 where and in-depth presentation and discussion of differences between the three military service academies is presented.

Initial teacher education programs lasted anywhere from 3-6 weeks in the Summer prior to the start of the academic year with the ultimate goal of ensuring each instructor was ready to begin teaching in the classroom at the start of the semester in the Fall. The components of the programs were focused on both orientation to the military institution and instruction in pedagogical practices. This orientation and instruction were delivered in partnership by both the institution in general and by the specific departments, including the science departments.

From the documents, a brief description of the US Air Force Academy's New Faculty Orientation can be found in their faculty handbook (United States Air Force Academy, 2019, pp. 50–51). Although extended descriptions were not found in either the Army or Navy's faculty handbooks, data collected during instructor interviews provided descriptions similar to the AF's program (United States Military Academy, 2014; United States Naval Academy, 2015). As found in the USAFA faculty handbook.

> *"All new faculty members and returning faculty members who have been absent from USAFA for more than one year are required to attend New Faculty Orientation (NFO)," pg. 50*
>
> *"The various faculty development workshops that constitute NFO programming typically revolve around, 1) how to apply evidence-based, learning-focused teaching practices; 2) how to create professional and appropriate teacher/student relationships and respectful, engaging learning environments; and 3) how to engage in sustained professional development." Pg 51*
>
> *"In addition to the faculty-wide orientation, all departments conduct their own faculty orientation prior to the start of the fall and spring semesters…As part of these departmental programs, all new faculty practice teaching before their first day of class. Required practice teaching sessions should consist of at least two classroom sessions with experienced faculty members observing and providing constructive feedback at the conclusion of each session." Pg 51*

The description indicated that attendance was mandatory for all new and returning personnel including both civil servant and military instructors. The document described elements of both orientation to the institution and pedagogic aims of the program. Programs were conducted by both the school as a whole and within each academic department. Training at the department level involved presenting department pedagogic practices as well as well as practice teaching. This element of practice teaching was common across all departments and all newly arrived instructors were required to perform practice teaching in front of experienced faculty or the department leader prior to teaching in a classroom with cadets. One description from each service academy will be presented in an effort illustrate service differences. An account from a department leader, who generally oversees the programs will be presented along with an account from an instructor who had participated in them.

Air Force Academy teacher education

This first account from a department leader in the Air Force describes some of the elements of their in-department training. In particular, it focuses on the evaluation of new instructors during practice teaching sessions.

> *"In addition to the to the [school wide] New Faculty Orientation, we run a program under [a senior instructor's] supervision where he and I formally audit each of the new instructors. We have a kind of nice grading rubric that sort of walks them through, introduction, subjects, objectives, your questioning style, your methodology. 'How did you assess? What was the pre-class preparation? How did you roll that in?' You know, those types of things, and it's constructive." – US Air Force, active-duty military instructor and department leader*

The department leader describes one of their additions to the school wide topics in the form of how they audit new instructors. Alongside a senior instructor, this department leader formally evaluated each new instructor and provided constructive feedback on their practice teaching. They demonstrated thoroughness as they had developed a rubric to check various aspects of teaching practices and classroom management. While not in the passage here, an element captured in another part of the interview was that in addition to feedback, gaining the department leader's approval during this audit was a requirement for new instructors prior to their start of teaching. This kind of audit or approval was mentioned by all department leaders at the Air Force and Army military service academies. Navy accounts below indicated that their programs appeared less formal. Before moving to the Navy, here is an Air Force instructor's account of their participation a new teacher program.

"[we completed] practice teachings of different lessons and received good feedback to kind of set expectations for how things would work in the classroom. Timing and board space management was one I didn't think of initially. It was helpful feedback for when day one started, I had at least some experience. It was it was nerve racking, but it worked out." – US Air Force, active-duty military instructor

This instructor believed that feedback provided on their practice teaching had the effect of better preparing them for certain aspects of teaching. This instructor also described the evaluation as "nerve-racking" which was a description that occurred in several interviews. Since they had never taught in their regular military career, they were thankful for the experience.

"So, we started with lesson two. And I think we had seven or eight new faculty, and you get lesson two, the next person does lesson three, [the next] lesson four, so by the time we've all gone through three practice lessons each, we were two thirds of the way through the semester. So, we saw most of the course and prepped a few of the lessons." – US Air Force, active-duty military instructor

In this instructor's account they indicated performing three practice teachings. By adding to this experience witnessing the three practice lectures of approximately seven other instructors, they were able to observe much for the course in advance. What is not directly mentioned here is that the lesson topics were controlled. A topic that will be presented later is how much of the semester is structured for instructors by their departments. At this particular school freedom to change lesson content in any significant was not allowed.

Naval Academy teacher education

As mentioned above, data from the Naval Academy indicated a less structured program.

"they'll kind of put together a lecture and present the lecture to one of the faculty members, either a military [faculty] that's been around for a while, or one of the senior civilian faculty, and they'll get suggestions on their teaching approach." – US Navy, civil-servant instructor

The department leader from the Navy described a less rigorous description of their program. The language about the program is looser and more described as "kind of" preparing a single lecture and receiving "suggestions" on their teaching from a sole mentor. In addition, the department leader did not mention their role as the gatekeeper prior to teaching in the classroom. This description was common across all department leaders in the Navy.

In examining an account from a participant at the Naval academy, data suggested not all instructors completed even the limited training described by the department leaders. This account

reveals the minimal amount of teaching development received by one instructor prior to being in front of an actual class.

> *"So, they gave me a textbook, and they said 'anybody will help you out if you have questions. Get in there and start reading the textbook, talk with other people see how they teach so you can figure out how you want to teach', … I literally had no idea what I was doing, I'm supposed to teach this class and I don't know a lick about anything. And so, my entire first year I couldn't have told anybody what was going on in the next chapter." – US Navy, active-duty military instructor*

This instructor's account appeared to lament the lack of preparation and direction they were given initially. While they indicated they were offered access to lots of resources, they reported that they struggled for whole first year in terms of being prepared to teach in advance of teaching days. While some instructors referred to the stress of going through the training programs, those stresses seemed to offset stress that would occur later in the semester. Lastly, we will turn to an account of teacher education and training from the Army.

Army teacher education

Data from both Army science departments indicated that their teacher programs were in a state of change. As the changes were someone what recent, most accounts included a "then" and "now" description of initial teacher education. This first account of change was provided by a department leader.

> *"So, I went through it when we used to call it the New Instructor Training Class (NITC), which I found to be implicitly pejorative and condescending. So, I'm actually the one that that advocated for the new moniker Faculty Development Workshop. Not to be, euphemistically you know, touchy feely, but to be more collegially inclusive. My experience going through that in 2002, was I think, very deliberately berating, condescending, emotionally abusive. I personally lost 10 pounds during the four weeks. The senior faculty openly would chastise and disparage [you] and while you were teaching, look for ways to provoke you or expose deficiencies in what you knew, and then unprofessionally attack you from there. I was profoundly disappointed in the lack of professionalism and collegiality of that era and vowed that if I ever came back here, I would see to it to remedy that." – US Army, active-duty military instructor and department leader*

This department leader's account was somewhat striking in its language and description. The leader utilized words such as berating, condescending, emotionally abusive in their description and indicated that the effect was to cause them to lose 10 pounds of body weight during the program. The intensity of the experience was so shaping that the instructor vowed that if they ever returned as the leader of that department that they would change the program. As just those circumstances occurred,

the department leader did in fact change the program to something more collegially inclusive which they felt was more appropriate for teacher education.

As the new teacher education program was somewhat new, one of the science instructors interviewed also participated in both versions of the training over the course of two different teaching assignments in 2008 and again in 2015. Their account supports the program differences.

> *It's changed a lot, I got to see it both times. When I first got here in the summer of '08, they used to call it NITC, new instructor training course. So that was not fun, it was rough. You had all these senior instructors, all old colonels, and everybody and you had to teach and go through 40 lessons. And they asked you the most impossible questions. They already knew you were nervous. We just laugh and joke about it now but it was just kind of part of the haze, and just probably like a big haze all summer. But honestly, when I was done with that course, I was so ready to be with the cadets. And I was when I got in the class. I was like, oh my God, that's the same stuff they've been training us. So, I was definitely prepared. They definitely prepared me to be in front of the cadets. But it was rough." – US Army, civil servant instructor*

Elements of this instructor's account echoed those from the department leader's. The training was described as "rough" and "not fun". In this account, practice teaching was performed in front of "all the old colonels" and "everybody" where the new instructor was presented with 'impossible' questions in a stressful environment. While described as a rough experience, at the end of the account the instructor chose to express the utility of intense preparation when they entered the classroom with actual students. Instead of vowing to change things, this instructor indicated an element of resilience was able to laugh and joke about the experience.

Elements of this description will likely resonate with many men and women who have served in any military organization. The instructor referred to their teacher education as a "haze" or the practice of roughly treating new initiates to a group. From the author's personal knowledge, hazing has been present in the military for a long time and is generally viewed as a pernicious practice difficult to root out. Cases of it are most commonly reported in initial training such as basic training, sometimes called boot camp, and when attending various military proficiency schools. While not limited to the military, the military may be more prone to hazing due to perceived utility in producing stress during training. It is interesting to note that these kinds of "stress tests" are regular part of military training when training for combat operations. For instance, some military exercises are termed "live fire" exercises because those training scenario use live ammunition. Trainees are

required to perform in the presence of very real mortal danger when there is actually no enemy threat present. From the author's personal background this can be possibly explained in the idea that armed conflict is likely one of the most stressful situations that can be encountered in life. The only way to adequately prepare to operate in such an environment is to reproduce as much of the stress as possible in peace-time training conditions. In returning to the instructor's account, the outcome of the intense and stressful teacher education was that when they were in front of cadets, the hypothetical combat scenario, they were "definitely prepared" for teaching.

This appeared to be a type of "light bulb" moment for the instructor when they realized the utility of the previous stressful training. This type of moment is likely common to many military service members required to operate in stressful environments. In returning again to the author's personal experience, it is difficult to understand the intensity of training in the moment. To understand why a drill sergeant is screaming in your face from 5 cm away for your lack of perfect recitation of some required quotation. It is puzzling to get in trouble for some spot or misalignment of a piece of your uniform. But the first time you are thrown out of perfectly functional airplane with a parachute strapped to your back you understand. The intense training of the past takes over and your mind automatically ignores the roar of the engines and the wind lashing at your face and calmly walks your body through the steps and procedures to correctly orient your earthwards trajectory and safely deploy a parachute. In that moment, you understand what "definitely prepared" feels like. While this kind of stress in teacher education is likely not appropriate for the "risks" that will be encountered in the classroom, it is possible to see how such a situation like this could develop in a military instructor education program.

In summarizing the initial teacher education programs, the degree of formality and rigor among the various individual departments seemed to fall along a spectrum and the descriptions from the Navy represented the least formal. The Air Force's description above fell somewhere in the middle while descriptions from the Army appeared the most rigorous. Further discussion of how these characteristics align with the various services will be presented in the next chapter.

In-service teacher education

The previous section described the teacher education programs required prior to the start of the official term. Each military service academy also had in-service teacher education programs that could be completed over a much longer portion of time. Their programs were referenced in the documents and interviews but there was almost no data collected on the topic. Accordingly, less data will be presented on the topic.

A description from one document described the following, "new faculty are expected to participate in a faculty learning community, a faculty mentoring circle, or some other sustained development program that builds upon New Faculty Orientation" (United States Air Force Academy, 2019, p. 51). It was learned that these programs were called by several names such as learning communities, mentoring circles, or teaching programs and were conducted both in group settings as well as individual focused. An account from a science instructor on an in-service program after their new faculty orientation.

> *"We continued to meet with our discussion group of maybe five to ten people once every other week, for that first semester, just to kind of discuss teaching pedagogy and different styles. We read chapters of a book just to discuss how we could apply some of the techniques to our classes. And then I started the Dean's teaching certificate program that they've set up here." – US Air Force, active-duty military instructor*

This instructor described their participation in discussion groups focused on improving their teaching. Participants discussed elements of teaching pedagogy and discussed chapters of a pedagogy book at various sessions. Uniformly across all accounts, these programs were described as much less formal of a program without any form of assessment by evaluators. This instructor mentioned that they also started another program referred to as the Dean's teaching certificate program. Other discerptions of these certificate programs usually involved attending a series of lectures and producing a number of reflective writing assignments. This instructors experience was not unique and most other new instructors reported participating in some sort of group. Here is an example from the Navy.

> *"They had a group for new military faculty members set up through the Center for Teaching and Learning. And that was like a Thursday lunch group. We worked through this book called Small Teaching by James Lang. And that basically just ran through the small things you can do in the classroom to like, actually encourage learning" – US Navy, active-duty military instructor*

This instructor described a similar group working through a book on pedagogy and continued on to say that they personally felt that they gained much benefit from this lunch group and book reading. They claimed that many of the ideas they gained from the program they were able to able to apply in the classroom.

Due to the broad nature of these programs I chose to limit my investigation of them, but elements of the survey were influence by their occurrence in the interviews. In summary these programs were available and required in some cases but not all instructors participated in. The next section discusses some of the reported practices designed to get teachers proficient in the classroom.

Common military training practices found in teacher education

This section presents how training and education practices found within the military might have made their way into teacher education practices at the US military service academies. It opens with an account collected from the Navy to present the topics of handling rapid turn-over through On-the-Job Training (OJT), learning other's responsibilities, and concludes with some discussion on accepting losses to expertise.

The following account was presented by a science instructor who had just finished a tour as a submarine officer. This account was collected during the demographics and background section of the interview and was in response to the question "have you been in a teaching or training position prior to this assignment?".

> *"Not officially. The training of junior personnel on a submarine is taken as an all-hands responsibility. So that's informally when people ask you questions, like you have to teach them how the submarine works because your life is eventually going to depend on them operating it correctly. And then more formally as an Over Instruction watch. So literally standing watch. As the Over Instruction watch you are the person on watch with an Under Instruction that is attempting to do all of your duties. I think that was probably the most stressful, of all the stressful things I had to do on the submarine. Being the over instruction regularly, it becomes very stressful. You need to think about how allow your Under Instruction enough rope that they can actually learn and do things, but at the same time step in before it becomes unsafe…And then they can stand watch on their own." – US Navy, active-duty military instructor*

This instructor explained also explained the background that submarines typically operate at sea for approximately three months at a time before returning to port for resupply. Every time the submarine leaves port it rotates a portion of its personnel and brings aboard a cadre of junior crew with no knowledge on how to perform submarine duties. This knowledge must be gained on the job,

at sea, during maneuvers. From the science instructor's account, when asked if they were in a training assignment they responded as never an "official" instructor. Yet from the description of submarine operations, their duties aboard involved extensive instruction of junior crew. The science instructor describes an ethos of training on submarines and states that training junior personnel is an "all-hands" responsibility. That ethos is supported by the motivation that everyone's life will eventually depend on their adequate training. This instructor described two scenarios of training with the first as simply answering junior personnel's questions in an informal way on submarine operations. The second scenario described training by standing watch as an Over Instruction. The account describes a type of On-the-Job-Training where the student, referred to as an Under Instruction, attempted to perform the instructor's, the Over Instruction, duties under close supervision. This type of instruction was reported as stressful since it involved a balancing act between allowing freedom to make mistakes and real risk to life and equipment. This description from the Navy was not an isolated description in the services. Aircraft pilots describe similar training scenarios where junior pilots are trained in flight by instructor pilots in a similar high-stakes environment. Intentionally stressful pilot training could also provide additional discussion on the historical accounts of hazing during the Army's new instructor training. It could be a case that a military members' belief that instruction in general needs to involve stress, which in-turn prompts them to introduce stress into the education of new science instructors.

Another concept from the submarine account was that onboard a submarine, there is a high degree of cross training. The trainee was learning all of the instructor's duties. From the authors personal knowledge, it is common in the military for members to both learn their superior's job and at the same time teach their jobs to junior personal. This happens to a further degree on submarines where officers will learn how to operate every part of the submarine, even if their duties at sea extend to only one component. The high degree of cross training on a submarine, and throughout in the military, has the obvious utility in combat scenarios where there is the "requirement for men who can quickly replace each other in the event of casualties" (T. R. Wilson, 1980, p. 23). The submariner completes their description with stating that after they are trained, the Under-Instruction can perform the skill on their own. These concepts of OJT and learning a progression of jobs were observed during fieldwork in the various science departments.

On-the-job-training

The first adapted practice was that of junior instructors participating in on-the-job (OJT) by attending classes of senior instructors prior to teaching the material themselves. An account from an Air Force instructor illustrates how an instructor was trained to teach during the course of teaching during a semester.

> *"I went, 'Wait a minute, I'm a brand-new instructor, and I get to watch someone else teach my material the day before that I have to teach my class?' One third of the faculty turns over every year. This is awesome, this is the best thing ever. Because now you've got this great standardization. I watched another civilian instructor teach 110 honors. And she was great, and I stole her slides. And I said, 'well I didn't quite like the way you did that. But I liked 90% of the other stuff you did. And I'm going to add this one extra slide because I think you need one more step before you go into that.' And off I went the next day and I taught it three times." – US Air Force, civil-servant instructor*

As some contextual background, due to scheduling of courses at all the service academies, the same material will be offered several times over a two-day period to various classes. New instructors were often given a teaching schedule on the second day allowing them an opportunity to observe the material they are about to teach presented by a senior teacher on the first day.

This instructor described this process by which they watched their material presented by a senior instructor a day prior to them presenting it to their class of students. This junior instructor then was able to utilize the other instructors teaching materials and make adjustments to them as they desired. This instructor was very enthusiastic of the practice with the rationale that one third of the teaching staff turned over every year. The one third estimation was accurate for the active-duty military instructors as most were on three-year assignments to teach. This type of OJT practice of junior science instructors attending classes was reported across all of the military service academies.

Always learning your boss' job and teaching your job to the next in line

The second practices reported in science departments was learning others jobs as well as your own. Similar to the submariner's account, instructors were always learning new jobs within their academic departments. Instructors reported moving from the introductory science courses to advanced topics. Instructors also reported the administrative roles of the various courses being quickly passed from individual to individual. As described by an Army instructor

"I was the assistant course director in the Spring of 18. And then in the summer, I took over as course director." – US Army, active-duty military instructor

Accounts such as these, where instructors went from teaching one semester to teaching and administrating the course the next, were reported across all the services. The position of 'course director' was similar across all academies and the role typically involved administration of the courses as well as assisting new teachers. After a semester as junior instructor, instructors were assigned as an assistant course director and then progressed to being the course director after. During this time, they would typically be training an assistant as their replacement. This progression was to account for the turnover of science instructors in the departments.

The effects of high turnover and a continuous loss of experience

High turnover adaptions of teacher training and education where most applicable to the active-duty military teachers. The departments involved both a mix of active-duty and civil servants' instructors but the civil servant instructors often remained in departments on a long-term basis. While the civil servants did participate in all the same kinds of initial training, after several years they would have rotated through all the positions were considered fully trained. After this they reported little teacher education. This experience led one senior civil servant instructor to note that it led to a an "expertise gap" between the military instructors and civil servant instructors.

"that's one challenge that I found here is that sometimes there is an expertise gap. And so, my students learn really early on, like, I am an ecologist, I've been an ecologist since 1999. Like it was my job." – US Air Force, civil-servant instructor

The "gap" mentioned was explicitly referred to the gap between military and civil servant instructors. The instructor had different views as to the quality of expertise in the classroom between them and some military instructors. They went on to describe that while the active-duty military instructors were quickly prepared for the classroom, their subject matter expertise was not as deep as the civil servant instructor's expertise who had remained focused in one area for a longer period of time, such as their expertise in ecology for the last 20 years. This instructor believed it affected the junior military's ability to field questions in a particular way. It could be that the military's definitions of 'junior' and 'senior' in terms of teaching experience align more with their use of the term in regards to proficiency at some skill, such as operation a submarine. In teacher education literature,

junior instructors are often considered those with less than 5 years of experience (add cite). By accepting such a high turnover of personnel, science departments will naturally have to accept a continual loss of experience to the department.

5.1.3 Summary of teacher selection and education

In summary, section 5.1.2 presented and discussed data on teacher education and training at the US military service academies. The data provided insight into answering the research questions on what are the contextual influences on teachers' beliefs and practices and described some data answering what are the shaping influences that effect how science instructors teach. A description of the formal teacher training programs was presented along with some practices of training in the military that were utilized in preparing teachers for the classroom. The next section will continue the theme of science teaching as a military operation and present how the leaders and departments control the teaching of their instructors on an ongoing basis.

5.2 Teaching in the military: hierarchy, standardization and camaraderie

Chapter 5 has been developing the theme of science teaching as a military operation. Section 5.1 presented data on how instructors were both selected and trained similar to processes within the military, this section will present data on how instructors and their departments operated in some of the same ways a military unit operates. Aspects of this operation include the use of hierarchy, employing standardization, and how a type of camaraderie developed among instructors. These data further answer research questions aimed at identifying the beliefs and practices of instructors as well as research questions on how context of teaching in military departments effect those teaching beliefs and practices.

Section 5.2.1 will present how science departments are organized and hierarchal in nature. Section 5.2.2 will present how elements of teaching are standardized across various classes. Lastly, section 5.2.3 will present how the shared experiences of the instructors bring about a sense of camaraderie and how instructors work to actively work together to accomplish the mission of teaching science.

5.2.1 Hierarchy and its influence on teachers' beliefs and practices

This section begins with how hierarchy presents itself within the military, it then progresses on to show how hierarchy presents itself inside the teaching departments between instructors, and concludes with a discussion of how hierarchy appears in the classroom.

Hierarchy in military units and science departments compared

Examining science departments organization is significant to this study as it provides answers to why some of the reported teaching practices were used. First, a discussion on how regular military units are organized will be presented, followed by an explanation of how the science departments were organized. This will be followed in the next section with two illustrations of how department leadership influenced the teaching approaches of their instructors.

Prior to a presentation of what is happening in the academic setting, it would be useful to understand some context of regular military operations. Certain principles in the art of war have proven themselves to be highly effective in achieving victory (Tzu, 2008). One of the primary principles is effective organization so that command and control can easily be maintained. This and other ideas can be trace back to the 5th century BC with the writings on warfare by Sun Tzu (Tzu, 2008). For example, a well-organized military unit is typically hierarchal and can be commanded such that every member brings their individual effort to bear on achieving a certain objective. With this massed effort applied against a military objective, chances of victory are improved.

Military organizations, like many organizations, are typically hierarchal in their organization. Commanders of large units have sub-commanders of smaller units organized under them often with several layers down to the individual soldier. Figure 25 illustrates how a typical battalion in the US Army composed of up to 800 members would typically be structured with companies, platoons, and squads as subordinate units. In additional to titles of position within the hierarchy, commanders of progress tiers hold military rank which is displayed visually on their uniforms.

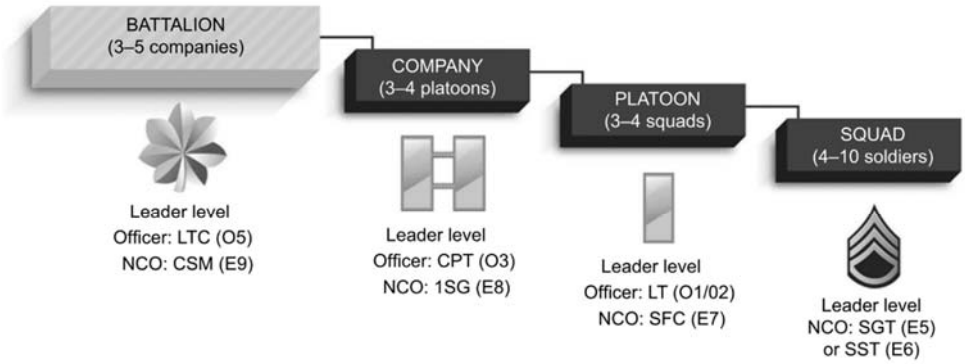


Fig. 1 US Army battalion organization structure (LTC, Lieutenant Colonel; NCO, non-commissioned officer; CSM, Command Sergeant Major; CPT, Captain; 1SG, First Sergeant; LT, Lieutenant; SFC, Sergeant First Class; SGT, Sergeant; SSG, Staff Sergeant)

Figure 25: An example of hierarchal organization in a military unit, figure as found in (Chukwura, Santo, Waters, & Andrews, 2019) (Image provided Courtesy of the U.S. National Library of Medicine)

As illustrated, each group is led by a leader holding a typical rank such as Lieutenant Colonel, Captain, Lieutenant, or Sergeant. This structure of tiered commanders is often referred to as the "chain of command" and is also in effect at the US service academies (United States Naval Academy, 2015, p. 24). Hierarchy is an efficient way of controlling a large group of individuals. In an actual combat scenario, this control is vital and disobeying orders can often result in mission failure and lives lost. Legitimacy to this authority is provided by the Uniform Code of Military Justice, the law that applies to all US military service members (U.S. Congress, 1958). Similar to combat unit structure, the various science departments at the US military service academies were organized in a similar hierarchal fashion. One example of this has been developed and illustrated in Figure 26.

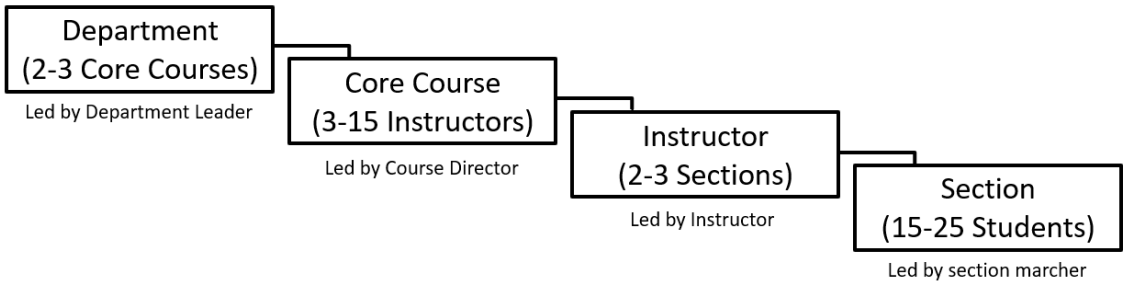


Figure 26: Hierarchal nature of science department as US service academies.

As Figure 26 illustrates, the science departments were all led by a Department Head or Chair, referred to as a Department Leader in other parts of this document. Each department offered 2-3 core science courses, core courses were required of all students at each institution (United States Military Academy, 2014). These courses were organized by a course director who would typically oversee the

teaching activities of 3-15 instructors teaching the same course at the same time. The instructors in turn had 2-3 sections of students typically 15-25 members in size that they would instruct during different periods of the day's schedule (Shell, 2002). Each section was led by a student section marcher who would perform minor administration of the class such as taking attendance or bringing the class to attention at the beginning of lessons.

The structures of both an active-duty military unit and an academic science department have been presented together to illustrates some of the commonalties between the two. They are both tiered organizations and the sizes of the individual units are in some cases very similar. A science class of students is of a similar size to a platoon. Military rank is also present among members in both cases. With similar organization presented, the following two sections will examine how hierarchy was observed at different levels. First between members of the department, in essence the practices and beliefs happening above the classroom level. The second section will present how the concept of hierarchy presented itself in the classroom and instructors' abilities to identify it and actively manage it.

Department hierarchy: identified and connected to teacher beliefs and practices

One of the central aims of this study is to identify the teaching practices and beliefs of instructors. The other central aim was to identify the teaching beliefs and practices supported by elements of the instructors' context that might influence teacher beliefs and practices. The department hierarchy and the department leader at the head of it is one such example of an influential element of the context. Two departments with the clearest data will be examined as a case study on how a department and its leader could influence beliefs.

The first department examined was at the Air Force's academy. The beliefs and practices of the Department Head will be presented followed by the beliefs and practices of the core course coordinator and concluded with the beliefs of two instructors at the bottom of the hierarchy. As a note, all department leaders were required to teach at least one section of science every semester in addition to their administrative duties. Additionally, all active-duty military department heads held the military rank of Colonel. Civil-servant department chairs in the Navy held academic rank such as professor.

Colonel is a very high rank in the US military and the last rank prior to general officer. Here are the Department head's statements on preferred teaching practices.

> *"I'm a big fan of getting them to do the right board work problems on the board. And then I like to walk around." [later in the interview] "If you ask me, 'what do I know is going to work?' the answer is, in the classroom, for everybody, that's board work. I have found that semester after semester after semester... And when I get feedback from the students, that's the very first thing they'll tell me is, 'Sir, the more board work we can do, the better'" – US Air Force, active-duty military instructor and department leader*

In this interview excerpt, the department head articulates their practice and emphasis on the use of board work, a teaching practice discussed more in-depth in Section 4.2.3. This Department Head also describes how they practice walking around during this type of learning activity. In the second quote the Department Head reveals a belief they hold about board work, that it is the preferred teaching practice and confidence in that it is going to work for "everybody" and "semester after semester". In the final quote they support their belief with personal observation of effectiveness and reported student feedback that puts the teaching practice as the first practice to be increased. Hierarchy also seems to be subtlety presented in the final quote above in the reported conversation between cadet and colonel when the department head uses "sir" when speaking in the voice of the cadet. From a personal perspective within the military, it is rare for those formalities to be omitted when interacting with a Colonel. The author, holding the rank of major during fieldwork, used the same formalities during the very interview these data were collected.

The next interview came from one of the core course directors in the same department. This individual represents the next link down in the department's chain-of-command. They held the rank of Lieutenant Colonel, one rank lower to that of department head. This course director had approximately a dozen teachers who they administrate in the teaching of one particular core science course.

> *"I focus on board work" and "I think the single technique that is most effective is board work, getting them out of their seats, putting them at the board" – US Air Force, active-duty military instructor and course director*

The next link in the chain echoes the practices and beliefs of the prior. They report a practice of focusing on board work and belief that is the single most effective teaching practice, views that are in alignment with the department head's views. As illustrated in Figure 26, this director would have a

number of instructors teaching the same course they were responsible for organizing. The presentation of beliefs and practices continues down the chain as data from two instructors is presented. The first instructor had several years of teaching experience in the department but held no military rank as a civil-servant instructor.

> *"The [students] love to see me demonstrate how to do a problem, and then have them do it. So now [I send them] up to the board"*
>
> *"And there's other people who maybe don't do any board work at all, I don't know, I haven't heard of that, most people will go to the boards and practice. Because again, you can't get good at it if you don't actually do it." – US Air Force, civil-servant instructor*

This instructor reported a practice of demonstration or lecture followed by using board work. They report that the students "love" this teaching practice. They continue to report their personal perceptions of the use of board work across their department. They indicate not knowing of any instructor that does not use the teaching practice. Lastly, they present their belief about the teaching practice of board work in that one cannot get "good" at something unless one "actually does it". This instructor shares several practices and beliefs with their department, that board work is the preferred teaching practice and that students possibly prefer it, a belief espoused by the department head.

A second and final account will be presented from the same department. This account comes from an active-duty military instructor also in the core course. This instructor had only been teaching for about 7 months and held the rank of captain. While the rank of captain is a middle rank in traditional military units with enlisted personnel, it was about the lowest rank of any military teaching faculty in these science departments. The instructor's teaching practices and beliefs can be seen as they describe their efforts to develop their teaching skills.

> *"Yeah, I think [board work] is a major emphasis for the department. From what I've seen, there really shouldn't be a lesson that doesn't have board work, as general advice from the department."*
>
> *"I try to have as much participation as I can. So, I try to minimize the amount of time of me talking and lecturing and have concept check questions. Those will mostly go out to the whole class and one or two people, or a couple people, answer it. And then I have… I've done… The department likes to do a lot of board work. So, you get groups, ideally, groups of two going up to the board working on a problem together and talking through it. It ends up not being that way, unless the teacher goes and patrols and make sure that they're on task in small groups, and people are actually participating. So, what I started doing recently is these worksheets where it's homework problems" – US Air Force, active-duty military instructor*

This instructor was in their freshmen year of teaching and reported a number of beliefs and practices. They report their understanding of their department's emphasis on the practice of board work, that no lesson should be taught without the use of board work. In their second quote they articulate the aims of their teaching practices and report trying to maximize student participation in the classroom by minimizing instructor talking or lecturing and by presenting concept questions to the whole class to be answered which only some students answer. As the instructor continues their response on their practices there is some nuance in their answer that needs to be discussed. They start with a phrase *"And then I have… I've done… The department likes…".* Two hesitations were recorded after "I have…" and "I've done" and then the response shifts to "The department likes…". The instructor shifted from statement of personal teaching practice to the preferred department practices. It is possible from the language of this excerpt that the instructor knows what the department "likes" and emphasizes but may have some difficulty in accepting board work as their personal practice. The instructor articulates what his department preferred teaching practice should look like but then somewhat honestly states "it ends up not being that way unless…". It is possible that this instructor doesn't seem to share the same conviction of belief in effectiveness of board work as other department members hold.

There could be a number of possible explanations for this lack of belief in the efficacy of board work. Perhaps due to the instructor's inexperience they are not confident in any particular teaching practice. Or perhaps they have not fully mastered the practice of using board work and the aspect of "patrolling" to enforce participation. Perhaps board work was a practice that does not work well with the instructor's personal teaching style. In a religious analogy, perhaps with additional exposure to the departments belief system surrounding board work they would finally be "converted to faith" in board work, despite personal results. This interview provided a snapshot of the instructor's current practices and beliefs. While outside the design of this study it would be interesting to interview this same instructor again at the end of their 3-year teaching assignment to investigate the dynamic nature of their teaching practices and beliefs. Finally, in perseverance towards developing teaching practices that maximize student participation, this instructor reported that they were experimenting with a new "worksheet" practice.

Combining these 4 accounts illustrates how teaching practices and beliefs might be shaped in a hierarchal science department at a US military service academy. Teaching beliefs and practices held by the department head, or commander, were identified down through each level of the science department's hierarchy. These discussions provide answers to several research questions in one department. Answers to research question 1.c "what are the beliefs and teaching practices supported by the department heads?" were presented. Answers to research questions 2.a "What are the pedagogical beliefs and practices of science instructors?" and 2.b "What are the shaping influences that effect how science instructors teach?" were also presented.

The extended presentation of data and discussion focused on only one department of the 7 science departments across the three military services. The Air Force science department selected as a case study was a fairly good representation of the 5 science departments across the Air Force and the Army. To support that claim a short account from the Army will be presented next after a short discussion on data collected from the Navy. It must be documented that the Naval Academy science departments were somewhat different in their hierarchy and composition. The five Air Force and Army departments were led by a military officer holding the military rank of colonel and academic rank of professor. The two science departments at the Naval academy were led by civil-servant department chairs holding the rank of professor and Naval science departments were composed of a lower ratio of active-duty military instructors to civil servant instructors. This finding contributes to a research question on identifying group differences and the next chapter is dedicated to exploring the differences between such groups as the Army, Air Force, and Navy. As a brief explanation, perhaps the concept of hierarchy and its influence on instructors teaching beliefs and practices was less visible at the Naval academy due to their lower amount of "militaryness" in the possible form of less military members and leadership inside the science departments.

A second account of department hierarchy will now be presented, but this account emerged from an Army science department. Rather than presenting the data in the same format, down through the chain, the account comes from one individual instructor's vantage point as they reflected on what they termed academic freedom and how change occurred in teaching practices. This individual's account was purposively sampled (L. Cohen, Manion, & Morrison, 2011b, p. 114) during field work

as they had a unique background especially useful in regards to answering research question and describe in Section 3.2.2 on participant sampling. As a member of the department, the instructor was positioned fairly high up in the organization but not the top. The individual had six years of teaching experience but split between two different military service academies, those of the Army and Air Force. The member was an active-duty officer holding the rank of Lieutenant Colonel who had served as a core course director during a time of transition from one textbook to another. Their military career experience in both the Army and Air Force was illustrated by their increased observation of how hierarchy played out differently between the two forces and they appeared to have reflected on a number of other practices of their organizations. It must be acknowledged that this account entails one instructor making generalizations about other instructors' teaching beliefs and practices. It might be preferable to let each instructor present their own voice but considering that three other interviews from the same department provided data that generally corroborated this senior instructor's statement, it was decided that their views were sufficiently valid. Their quote is extended and needs some prefacing. The instructor described one example of how military hierarchy and influence was demonstrated when a department head made the decision to switch from textbook to another. In addition to hierarchy in the department, they also add a concept that active-duty military instructors might respond differently to the hierarchy than civil-servant instructors. The original text book, referred to as "Moog", was authored by R. Moog and J. Farrell (Moog & Farrell, 2017), and the department had been using it and the corresponding teaching practice of Process-Oriented Guided Inquiry Learning (POGIL) (Moog & Spencer, 2008) that the textbook was designed for. Other interviewees confirmed this aspect and added that the authors of the textbook had been invited to the department to offer workshops on how to use the POGIL teaching practice in the classroom. The text book defined as Tro (Tro, Fridgen, Shaw, & Boikess, 2017) was a more traditional styled science textbook not designed to be accompanied with any particular teaching practice. The term "academic freedom" is also used but appears to be more about the freedom of instructional practice as opposed to a concept related to freedom of speech in academic settings.

> *"In terms of academic freedom here, you've got a bit of a divide on how that works. From a [active-duty] military [instructor] standpoint, you've got individuals that are used to taking orders and doing things based off of that. And then you've got the civilian [civil servant*

instructor] side of things, which is, from their perspective, purely academic. And so, when the Department Head says something, the [active-duty] military [instructor] is going to go, or attempt to try, to meet the intent as much as possible based off of what the Department Head's guidance, or implied guidance, happens to be. Whereas at the other end of things, the civilian [civil servant instructor] is going to say, "this is this is infringing on my academic freedoms, you provide me [with] guidance, not necessarily directions that I have to follow". And so, they'll adjust how they see fit, based off of whatever the particular situation has to be. Big case in point was when we were doing the Moog versus Tro [textbook and pedagogy] transition. There were some civilians [civil servant instructors] that were very strong in wanting straight up Moog. While all the [active-duty] military [instructors], as soon as Colonel [Department head] had an implied intent that, 'we need to re-evaluate [Moog]'. They took that as we need to just stick solely with Tro. And so based off of that, their teaching styles immediately changed from implementing more Moog type of activities to straight up using the Tro textbook based off of that [guidance], as an example. And then when we tried to push this straight up Tro text, some of the civilians [civil servant instructors] got upset because they felt like they didn't like the direction that it was going. So, it's different." – US Army, active-duty military instructor

There are several observations that can be extracted from this extended account that correspond and differ to the hierarchy account from the Air Force. In similarity, this instructor described a hierarchy in the department that when the department head made a decision, reportedly the active-duty military members of the faculty immediately shifted their teaching practices. In this instance from the POGIL method and teaching practices to what other interviews described as an array of practices.

But this account differs from the Air Force account in that there were reported differences between the civil servant instructors and military instructors. In the Army account, some of the civil servant instructors are portrayed as viewing the military hierarchal authority differently to that of an active-duty military instructor. This instructor proposes a reason that because of the military background of "taking orders" in more traditional active-duty service that a military instructor would be more inclined to identify the "commander's intent" and seek to fulfil that intent as a way of following orders. They also suggested that some civil servant instructors might take the commander's intent more as "guidance" and not a required "direction". The instructor then illustrates their assessment of active-duty and civil servant instructors' practices with the recent textbook and teaching practice change. They indicated that the active-duty military took the commanders guidance on a new textbook and that "their teaching styles immediately changed". They further state that some civil servant instructors were upset as they didn't "like the direction".

While the Air Force account appeared to indicate a degree of solidarity across the department, it is likely that with any group of instructors, there is a spectrum of beliefs and practices. The one Air Force civil-servant interviewed could have been a non-representative sample of the rest of the civil-servants. From the interviews, hierarchy did appear to be a way in which instructors' teaching beliefs and practices were formed. To investigate if these teaching beliefs and practices were representative of the whole population, survey questions were developed to explore each instructor's beliefs on elements of hierarchy

Survey data on department hierarchy

Three questions were designed to explore the instructor beliefs on desirability, occurrence, and value of direction from department leadership in regards to teaching science in the classroom. Table 20 presents the combined responses across all three service academies.

Table 20: Survey data presenting instructor beliefs on the desirability, occurrence, and value of direction on teaching practices provided by elements of department hierarchy.

	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
B2 It is desirable for department leadership to provide direction on how to teach science in the classroom.	5	5.4%	18	19.4%	13	14.0%	37	39.8%	20	21.5%
I11 I receive a lot of direction from my leadership on how to teach my science classes.	25	26.9%	29	31.2%	20	21.5%	14	15.1%	5	5.4%
I13 My leadership provides valuable direction in regards to teaching practices.	8	8.6%	3	3.2%	33	35.5%	37	39.8%	12	12.9%

Over 61% of respondents agreed with the belief that department leadership *should* provide direction on how to teach science. The wording of this question is a bit vague and might have been improved with the inclusion of what kind of specific direction but as written over half of instructors agreed with the belief that direction on teaching from the department was *desirable*. In instructors' report on the practices' occurrence, only 20% of instructors reported that they did receive a lot of

direction on how to teach. So, while they believe it should happen, less report that the practice does happen. As to the value of the direction, over 52% of instructors agreeing with the belief that direction provided by their department leadership was of value.

Unfortunately, no survey question directly asked if instructors believed that department direction had directly influenced their teaching. But it is possible to answer this question by re-examining data presented in section 5.1.2 on teacher education. The hierarchy of the department and department direction was employed through a number of activities, the department initial teacher training and the department continuing teacher education were two ways in which instructors were influenced. Table 21 represents a portion of those data and provides answers on if activities instructors believed they were influenced by department direction through teacher training.

Table 21: Instructor beliefs about the influence of department teacher training on their teaching practices

	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
I6 My teaching has been influenced by department training provided on arrival.	13	14.1%	12	13.0%	10	10.9%	26	28.3%	31	33.7%
I7 My teaching has been influenced by continuing department training.	16	17.2%	10	10.8%	19	20.4%	34	36.6%	14	15.1%

Over 62% of instructors agree that they were influenced by their initial teacher education and almost 52% agreed they were influenced by continued department training. As teacher training is one way for department leaders to shape their instructors, these quantitative data support the interview accounts presented on department hierarchy and its influences on teaching practices and beliefs.

In conclusion, this last section focused on how military hierarchy was present in the science departments and how it might have influenced teacher beliefs and practices. But just as there are many levels of hierarchy in the US military, from the US president as the Commander-in-Chief over the US miliary down to the lowest ranks, hierarchy not only existed between in department, but also in the

classroom setting between teachers and students. It is this aspect of military hierarchy that will be examined next.

Hierarchy in the classroom

This next section will present data on how some of the hierarchal nature of the military presented itself the classroom between students and instructors. It will present two reported types of hierarchy and how some instructors viewed their positions or identities within these two hierarchies. Additionally, it will present how some instructors actively manage their identities to change their positions within those hierarchy or move between them.

Hierarchy within the military was described above. Since every single student at the US military service academies is also an active-duty military member holding the rank of cadet or midshipmen students are typically made very aware of their position near the bottom of this military structure during their initial "boot camp" indoctrination (United States Naval Academy, 2015, p. 24). However, military students are also part of another hierarchy. Cadets and midshipmen are part of a traditional hierarchal structure between teachers and students that likely exists in many classrooms. This is a relationship that has had been examined significantly in science education literature and even as it pertains to its effects on the teaching and learning of science (Cornelius & Herrenkohl, 2004; Haverly, Calabrese Barton, Schwarz, & Braaten, 2020). In summary then all students at the US military service academies are members of both the military and student-teacher hierarchies which is the same for all active-duty military instructors. However, while all civil-servant instructors share the student/teacher hierarchy, they do not share in the military hierarchy and nor do they wear uniforms as proof of their lack of membership. The management of membership or identity referenced was the practice of instructors to adjust their positions within a hierarchy.

The teaching practices and beliefs of instructors presented in this section generally fell into two categories, practices associated with classroom management and those associated with the teaching and learning of science. As presented in section 3.2 during the development of interview questions, instructor practices and beliefs related to hierarchy or power in the classroom were discovered during interview piloting. Initial findings from piloting suggested that some teachers

believed that the military hierarchy had an impact on their teaching and questions were developed to explore this area. Analysis of the data from these newly developed questions suggested that instructors held a variety of beliefs about their membership in these hierarchies and they reported practices to best position themselves for improved science teaching. But while some features of the hierarchy might help in one element of teaching science, they also reported it might be challenging for another at the same time. For example, an instructor might report that the military hierarchy was useful to draw on to maintain a high level of classroom management, but that same hierarchy might also present a barrier to the free exchange of intellectual discussion in the learning of science in the classroom. Data will now be presented to let instructors support these claims.

The following excerpt was provided by an experienced civil-servant instructor while discussing their observations on teaching at a service academy as compared to their experience teaching at other institutions.

> *"[cadets] always have to be respectful, but they start to realize early on in my class, that interacting with me, or asking me questions, has nothing to do with respect. But sometimes I think in some classes, they're not allowed to interact. There's this barrier, there's a hierarchical barrier or something where they just feel like they can't ask a question, because it's being insubordinate. Or sometimes, I feel like some [other instructors] might not have the expertise to answer a question or to know their knowledge limitations. And so, if a student asks [the instructor] a question, they take it personally. And that is probably higher here than I've seen in other places" – US Air Force, civil-servant instructor*

This instructor articulates that in the classroom two types of norms are sometimes applied to practices, such as asking questions. Certain practices, such as students asking questions about scientific content, could be viewed from either the academic lens and have "nothing to do with respect" or from a military hierarchal lens where asking questions could be associated with questioning orders or "being insubordinate". While not captured in this excerpt, the instructor indicated their belief that it was generally the active-duty military instructors who would take offense at questions and present the hierarchal barrier and indicated one possible reason for this could be that these instructors lacked scientific expertise. The civil servant instructor believed there was a difference between asking academic questions in the pursuit of knowledge and asking questions as a way questioning orders in an act of insubordination. They also believed that this was a barrier to class interaction, and by extension a barrier to the teaching and learning of science.

This particular quote is useful in adding voice to the claim of the existence and interaction of two hierarchies and the potential reasons for science instructors to desire to control them to best facilitate science teaching. Additional accounts will now be presented to illustrate a number of other beliefs. The first instructor accounts that will be presented are from military instructors who presented beliefs that academic settings were very similar to a military hierarchy. This type of belief led an instructor identity labelled as the "classroom commander".

Military concepts about a teacher identity: the classroom commander

The following excerpt was provided by a junior active-duty military instructor and includes their account of advice received from their department head upon arrival to teach.

> *"Coming in I felt more pressure to be more the classroom commander"*
>
> *[interviewee then asked to describe the term]*
>
> *"you're the boss in your classroom, [the department] is not going to tell you what to do. You get to manage your classroom however you want to as far as discipline or that type of a thing. Coming from a military background hearing the term 'classroom commander' came with a whole lot more responsibility tied to it, like you are responsible for the success and failure of every one of your students and you need to be the boss, you need to be in control at all times. Because, if you're not, 'Airmen are going to die' or the stereotypical [kind of thing]" – US Air Force, active-duty military instructor*

This instructor was encouraged by their department leadership to view themselves as "classroom commander" when they arrived at their teaching assignment. The instructor describes certain practices and beliefs that would be held of a classroom commander. In addition to aspects of empowerment with "we're not going to tell you what to do" the military member believed that the model carried a lot more responsibility than simply classroom management. They identified some of their personal difficulties with using a military term such as "commander" in an academic setting. They articulated that in a military setting a commander's position carries more responsibilities such as increased personal responsibility for success and increased personal culpability for failure. The instructor adds a bit of sarcasm as to the consequence of not fulfilling the role of the classroom commander, "death". It seems plausible that the intensity of the military version of "in control" extended to the classroom could create the situation described above by the civilian instructor where students would see questioning an instructor as insubordination of the 'classroom commander'.

From the authors personal experience of 23 years in the military, “death” is usually the sarcastic response for the consequences of any violation protocol or lack of diligence. “Hydrate *or die!*” was the common phrase heard during the authors experience at boot camp, as opposed accurate advice of “stay hydrated so you don’t suffer muscle cramps during this next forced march”. While the origins of this type of sarcasm are likely unknowable, sarcastic irony is a reasonable attempt at levity within the military. Such an attitude might have been developed in response to dealing with the possibility of the grim consequences of failure within a profession that trains in the use of lethal force (Ford, 2020). Perhaps a “classroom commander” approach might be the preferred approach for a military instructor teaching soldiers in the operational use of live hand-grenades, a training setting where learning presents a legitimate risk to life and limb. In returning to the instructor’s account, their description of responsibilities of a commander appears to be responsibilities not typically levied on instructors in the science classroom environment. It seems a hard to task to find a scenario in the teaching of science where the results of poor teaching would be death.

The term “classroom commander” was not explicitly used by any other instructors but some other accounts seem to model a version of bringing a military mindset into the classroom. A previous instructor referred to moving around the classroom as being on “patrol” and a marine corps officer at the naval academy described “running” a class.

> *It's all the same stuff, I think. I've never had any issues of that in my class, because I think it's very easy. I'm just very objective about, about everything, and then you run it like you would anything else in the military” – US Navy, active-duty military instructor*

In this excerpt the instructor was referring more to aspects of classroom management rather than practices of teaching science. This instructor reported the practice of running their class like they would run anything in the military. They believe that it is very easy and that they are able to remain objective “about everything”. But as outlined above, a hierarchal identity employed for classroom management might introduce hierarchal barriers to academic learning.

However, some instructors, and in this case a senior military instructor did not believe that the presence of this military hierarchy need to be adjusted at all. Similar to the marine officer, several other instructors believed there was no need to make any adjustments to their military hierarchy in the

classroom. When the interview question of trying to manage this aspect was presented to one department head, they believed the very idea was "silly".

> *"I think it's silly. The cadets know what this place is all about…To me, it doesn't matter what you wear, it doesn't matter who you are, you're the facilitator, you ought to be able to just facilitate. And I don't see any issue at all with cadets ever feeling that. I mean, there is no hierarchy, but they do understand they are in the military" – US Army, active-duty military instructor and department leader*

This department head seems to be expressing a number of beliefs about their view of hierarchy and cadets' views of it. Their statement of "cadets know what this place is about" and "I don't see any issue with cadets every feeling that" suggest that this instructor believes that cadets fully understand both aspects of being a member of the military hierarchy as well as being a student at an institution of higher learning. The quote further does on to show that they believed that that military hierarchy had no impact on an instructor's ability to "just facilitate" cadet learning. This department head held the rank of colonel and had an impressive military resume with over 30 years' experience in the Army leading units of up to 1,000 members in combat operations. It appears unlikely that cadets, for educational purposes, could ignore the impressive military aspects of this instructor as they were dressed in a uniform decorated with ribbons and hold a rank very near the top of the military hierarchy.

This instructor believes on one hand that "there is no hierarchy" and on the other simultaneously that "they understand they are in the military". This duality of beliefs appeared to be an example of the non-consensus of belief systems described by Pajares (Pajares, 1992). This instructor was so convicted in their beliefs that for an instructor to seek to actively attempt to manage this type of hierarchy would be "silly". But as presented in the next section, there were a number of instructors that disagreed with this belief and practiced the management of hierarchy.

Active management of classroom hierarchy: military members as academics and academics as military members

This section presents different ways that instructors managed the effect of hierarchy in the classroom. It presents an account from a department head on the issues as well as several practices by instructors themselves to change their hierarchy and its effect on teaching science.

As the previous section ended with an account of one department head thinking little of active management, here is an alternative account from another department head at the same institution. This department leader acknowledged that there could be issues with hierarchy and relayed their guidance given to their department instructors.

> *"The way that I managed that is, I remind new faculty and older faculty, like everybody is an intellectual colleague…so I think that gets past the power dynamic, we used to have some pretty traumatic power balance issues, and in terms of how that came across in the classroom, it was unhealthy, in the junior rotational [military instructors], captains with four or five, six years [experience] power tripping like an airborne infantry company commander" – US Army, active-duty military instructor and department leader*

This department leader begins with report that in the past there were "power balance issues" in the classroom that were unhealthy. They related faculty attitudes during teaching to those of "power tripping" airborne infantry company commanders. These type of leadership positions within the military operate in environments where leadership is a rigorous job due to the nature of those mission.

> *"The infantry operational environment is uncommonly lethal and unforgiving. Yet, junior infantry officers must succeed and simultaneously overcome the developmental challenge of preparing to operate in nine different infantry formations" -(Thorne, 2017)*

Airborne infantry officers are trained lead groups that parachute out of moving airplanes at an altitude of 1,000ft or less, in an active combat zone, hit the ground and immediately engage in combat with the enemy. This is one of those types of activities where incorrectly performing almost any step of this assault will result in loss of life. Leadership of this type of activity requires taxing attention to detail and strict control. This department head seems to suggest that the weight of this responsibility can lead to "power-tripping" and that prior commanders of this type who have rotated into becoming academic faculty bring that intensity into the academic environment. In response, this department head actively reminded new and old faculty to treat everyone, including students, as intellectual colleagues. Their concept of intellectual collegiality was developed to get past the "power dynamic" presented by the military hierarchy. This advice direction was provided by the department head to their instructors but the instructors also reported their own efforts to manage hierarchy.

There were a number of instructor practices reported that were designed to change, or at least acknowledge the difficulties presented by a military hierarchy in the classroom. While some

instructors either were able to identify that the hierarchy might cause barriers to learning in the classrooms, others went further to change the hierarchy or its perception in various ways. When asked if and how individuals managed it there were a number of brief answers. Here are three accounts, one from each military service.

> *"there's always kind of this give and take relationship, and I don't think that's it's bad, but it needs to be acknowledged and managed, otherwise it can be very adversarial" – US Navy, active-duty military instructor*

> *"So, relating to them, communicating with them, being humble, and recognizing where your flaws are and the limitations to your own knowledge and understanding of the material." – US Air Force, civil-servant instructor*

> ***"****I know colonel [Name], one of the things that he does when he starts his class. He pulls off his colonel rank and puts it on the desk. And he says 'I'm Dr. [Name] right now when this door is closed, I am Dr. [Name] until I have to be colonel [Name], but don't make me be colonel [Name]'. He tries to level that playing field." – US Army, civil servant instructor*

Each account from each service indicates a different hierarchal management process. In the first account, the naval officer answered broadly on their practice and that there needed to be a practice of "give and take". From a larger segment of the interview this give and take was about control of the class, the instructor selected times to trade class control in exchange for class involvement. If they tried to control too much an element of the class could become adversarial. Unfortunately, more specific practices of this management were not provided.

In the account from the Air Force the officer reported a practice of relating with humility and open acceptance their personal flaws and limitations of the scientific material. As a commander, one is expected to have most answers to most situations, there are US military training programs for new commanders where they learn how to handle a wide variety of situations they might encounter when leading a unit, many of the topics cover "what if" scenarios such as how to bail a subordinate out of jail should the situation ever arrive (Anderson, 2016). This instructor's report of practicing humility directly addresses hierarchy along with their practices of recognizing flaws and limitations in their knowledge as they can now approach scientific learning as peers with their students.

The last account was provided by an Army civil servant, it details the secondhand account of how a fellow active-duty military instructor reportedly removes their rank from their military uniform and explicitly retitles themselves with their academic credentials of "Dr." in an effort to "level the

playing field". This account illustrates that the officer is aware of the barriers presented by their rank and actively tries to remove it by removing the physical rank. Their practice is intentional and their words are very clear but whether they are successful at "leveling the playing field" might require discussion. Do students feel that the hierarchy has been removed with the simple removal of rank, especially when a warning is issued that the rank can be put right back on if someone "makes them"? In addition, is the new assumed title of "doctor" a title of leveling? Perhaps this is only a swapping of preferred hierarchies, effectively trading a high position in one for a similarly high position in another. It is unclear if this practice of swapping of identities actually removes the hierarchal barriers between instructor and student that could negatively affect the teaching of science.

In the three hierarchal management accounts just illustrated, the management of hierarchy was performed by an active-duty military instructor to manage their position with military students. But there was also an account of the exact opposition management where civil-servants attempted to insert themselves into the military hierarchy. Here is a description of that account.

> *"When I got here, the other civilians [civil servants] warned me that sometimes the students are disrespectful to the civilians, right? In fact, the military [instructors] even warned me of that. I said 'well, I'm just going to be who I am, and go out there and do what I do'. And so, I put up an [old] picture of me in uniform, on the very first day. [then] I have zero problems with respect." – US Air Force, civil-servant instructor*

Prior to taking a position as a civil servant, this instructor had a distinguished career as a military test pilot and retired with the rank of Lieutenant Colonel. Becoming an US Air Force test pilot is an extremely competitive process and it is a mark of a distinguished Air Force pilot career (Gray, 2010). Since roughly half of the cadets at the Air Force Academy will end up commissioning as pilots, they are typically familiar with this type of achievement. When this instructor arrived to teach, now as a civil servant, they were presented with accounts of disrespect from military students directed at civil-servant instructors. They reported a practice of showing a picture of themselves in uniform next to their jet aircraft in an apparent effort to re-insert themselves into the military hierarchy. The instructor's practice is designed to address classroom management and after performing the hierarchy management practice they claim "zero problems" with respect. But this practice would only be available to those civil-servants who had previous military experience.

This evidence seems to suggest that for at least this 'civilian instructor' believed that students respond differently to active-duty military instructors, as opposed to civil servant instructors. In investigating whether this belief was held more widely a survey question was developed with the instructor responses presented in Table 22.

Table 22: Instructor beliefs on whether students received military instructors differently

	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
B5 Military instructors are better received by military students than civilian instructors.	11	12.0%	16	17.4%	35	38.0%	23	25.0%	7	7.6%

Instructors' beliefs on whether military students received military instructors better were quite varied and about an equal number of instructors held a belief in favor and against this idea but the majority were neutral and believed it did not matter. This distribution of responses on the survey seemed to agree with the varied ways instructors chose to address hierarchy in the classroom in the interviews.

The concepts of a military hierarchy and an academic hierarchy have been presented, but likely there are a multitude of other hierarchal systems that could have been analyzed. Not only could there be additional systems but individuals could move between those systems on a dynamic basic. One last account will be presented that illustrates the idea of another hierarchy and movement between them.

Hierarchy beyond military or academic: trainer/trainee roles and positional reversals

In addition to instructors understanding about military and academic hierarchies in the classroom, with some instructors actively managing them, other hierarchies existed and presented dynamic environments and role reversals. One account collected indicating how just one such role reversal could occur. This account comes from a science instructor who, in addition to teaching in the science classroom, also participated in the aviation program at the Air Force academy. These aviation programs offer cadets the chance to learn airmanship skills in light aircraft and are almost exclusively cadet run programs (United States Air Force Academy, 2019). Officers do have involvement in these

airmanship programs but typically in an advisor role. Since programs are cadet run, qualified cadets teach other cadets how to fly gliders and other light aircraft. The following encounter occurred when a science instructor decided to become one of the officer advisors on an airmanship program. This officer was required to go through glider pilot training with a former student as their instructor pilot.

> *"I had a cadet as a freshman in my physics class. And then one year later, I was in upgrade to be a glider instructor pilot, and he was my instructor. So, we're walking out to the plane and he's getting ready to teach me how to fly the glider. And I made some kind of comment to him. I said, 'so is this where you get your revenge?' And he looked at me says 'Na Sir, I got a B [in your class], you'll be fine'. So, it was on his mind too that we had flipped roles. I was instructor in class, and then he's teaching me to fly gliders." – US Air Force, active-duty military instructor*

The new hierarchy to be presented is a hierarchy within the crew of an aircraft. Inside the aircraft, military rank means almost absolutely nothing and hierarchy is established by the flying credentials of individuals (Carretta, 2000). This hierarchy can be supported by the author's personal experience in the Air Force. The author is not a member of the aircrew community but they have several lifelong friends who have served as aircraft pilots for decades. One close friend served as a transport pilot for the US Air Forces in Europe (USAFE) and transported the commander of that major command on a couple occasions. Even though the USAFE commander oversaw over 24,000 troops and held the highest rank of four star General, during flight they were "outranked" by the transport pilot serving as the aircraft commander. Aircraft commanders hold supreme authority of the aircraft regardless of the other passengers or aircrew (McGreevy & Otten, 2007). In a similar fashion an instructor pilot holds absolute authority over a pilot in training. Instructor pilots are responsible for ensuring the lesson does not end in loss of life or aircraft. Pilots in training report that these scenarios can be extremely high stress. Again, from personal accounts from pilots, this is one of the scenarios where the instructor pilot holds full authority on certifying "upgrading", or passing a qualification check. While not a regular practice, an instructor pilot can make the training process more or less difficult based on personal choice and pilots in training having no recourse to object.

In returning to the science instructor's account, they have now entered a new aircrew hierarchy and the former student holds now holds authority over the seasoned officer. The science instructor realizes the situation and questions if the former student will exact their "revenge" from experience in the science classroom. The student answers "Nah sir" and reports that upgrade process

will not be more painful than necessary since they received a "B" in the science instructor's class. Both actors seem to be aware of the role reversals. In this example the position of instructor and student were flipped between the two individuals and an aircrew hierarchy went into effect. In summary, hierarchy in the departments and classrooms were reported. This hierarchy was sometimes dynamic and managed by instructors.

This concludes a discussion on military hierarchy and how teacher practices and beliefs were influenced by military hierarchy in their departments and in the classroom. These teacher beliefs and practices contribute towards answering the research questions on beliefs, practices, and influences. The next aspect of teaching as a military operation is on how standardization and uniformity among science instructor was a part of their teaching practice.

5.2.2 Standardization and its influence on teachers' beliefs and practices

This section explores elements of how the military practice of standardization, or uniformity, relates to the teaching practices and beliefs of science instructors at the US military service academies. The idea of standardization was explored as it provided a useful framework for viewing teacher beliefs and practices as answers to research questions. A description of standardization within the military will be presented, followed by a description of how many elements of the administration of science classes occurs. The section concludes with both current and historical accounts of how teaching practices were or were not standardized.

The idea of standardizing something to make it consistent or regular is a widespread and longstanding practice within the US military (Elwell, 1970). Advantages of standardization within a military fighting force are broad and include increased efficiency, reduced cost, and increased interoperability. One example might be standardizing all radios of NATO nation members to provide interoperability between allies on a battlefield (Williams, Perry, & Candy, 1978).

On a more individual level, many aspects of life, such as personal appearance in the form of haircuts, are standardized for all military members. Regulations dictate a large portions of personal dress and appearance, from standards of the wearing a military uniform to standards for personal appeared such grooming, hairstyles, and standards for tattoos and body piercings (Headquarters

Department of the Army, 2021; Secretary of the Air Force, 2014a). As members of the US military, all students and active-duty military science instructors are required to abide by these standards. This standardization had the effect of creating a student body and half the teaching faculty that visually appeared homogeneous in nature. One exception was the civil servant faculty, since they were not military members, they were not required to keep the same standards. But these instructors were also not fully excluded and civil servants were directed to follow certain dress codes to match the formality level of their military counterparts (United States Air Force Academy, 2019, p. 91; United States Military Academy, 2014, p. 20; United States Naval Academy, 2015, p. 24). Just like uniforms and appearance, the US military service academies standardize many elements of teaching and learning experience. The practices to be examined are the administration and curriculum science classes.

Department standardization: Uniform curriculum and administration

There are a number of elements associated with the curriculum and administration of science classes that were standardized. At the institution level, it was discovered during field work that many elements such as class size, schedule, and required classes for graduation were standardized above the department level (United States Air Force Academy, 2019; United States Military Academy, 2014; United States Naval Academy, 2015). Class size was standardized to typically 20 to 25 students per class. Classes were standardized to a particular schedule or "schedule of calls" at each institution. Each institution also standardized which set of academic courses, called "core" courses, would be required of every student in addition to any major classes. The rest of this section will focus on the standardization of these core classes. Non-core classes were omitted as they represented a much smaller percentage of classes offered and were typically much smaller in enrolment. Before presenting examples of standardization, it must be reported that a higher degree of standardization was reported in the Army and Air Force institutions as opposed to the Navy. These group differences will be presented very briefly in this section but then more thoroughly in the next chapter on service differences.

Typically, an introductory year of physics, chemistry and biology was included as part of the core and required for all students regardless of their major. US military academies do not follow a practice reported in other higher education institutions in the US(?) where large enrolment science classes of several hundred students per section are taught by limited number of instructors (Deslauriers et al., 2011). As an alternative, they typically teach approximately 1100 core students in a standardized class sizes of 15-25 students per class or section. Continuously providing this education to roughly one quarter of the entire student body was a major operation for each science department. Figure 27 attempts to graphically represent this organization of a large number of small sections. Possible rationale for this organization was presented in section 4.1 with the concept of "preparing officers" as the central aim of each institution. Smaller classes could result in better interactions between instructor and student and more focused attention on developing officers.

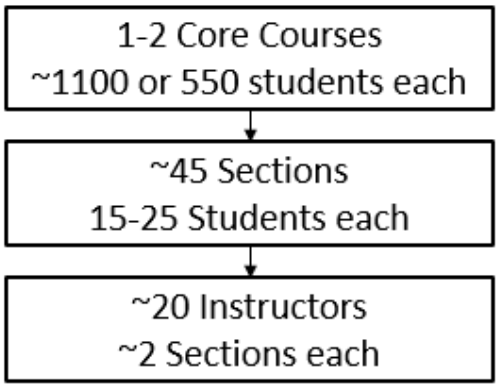


Figure 27: Typical core class organization. Approximately 1,000 students being taught in sections of around 20 students. Each section is standardized to the others in many ways.

A high degree of standardization occurred across sections in a core course. Core courses instructors typically taught between 1 and 3 sections and were required to standardize with up 20 other instructors in terms of curriculum, such as which textbook is to be used, their teaching schedule throughout the entire semester, the assessments they used and lessons involving laboratories and most graded events were also standardized. Instructors were required to use a standardized textbook selected by their department.

> *"You're given a textbook" – US Army, active-duty military instructor*
>
> *"We had the same textbook for everybody" – US Navy, civil-servant instructor and department leader*

"We've got a pretty strict curriculum, we follow this textbook" – US Air Force, civil-servant instructor

In addition to practice textbook standardization, the teaching schedule is standardized across all instructors in a course with instructors reporting teaching the same topics on the same day. In addition to schedule standardization, instructors utilized standardized assessment tools such as exams. Exams were provided by course directors and administered to all students at the same. Here are examples of both.

"They're all going to cover the same content on each lesson" – US Air Force, active-duty military instructor, course director

"We do common exams here for the most part, everybody takes the exam at exactly the same time." – US Army, active-duty military instructor

"You don't write your exam, you grade a part of the exam, you have a schedule when you have to give it" – US Air Force, civil-servant instructor

"The course coordinator, who writes the syllabus, also writes the final" – US Navy, active-duty military instructor

"The core course is more constrictive. It has to be because you've got 19 instructors doing the exact same thing" – US Army, civil servant instructor

These accounts from across services and departments report standardized teaching practices. As previously mentioned, an exception to the exams was reported at the Naval academy where only the final exam was standardized across sections. Instructors were provided the final exam, a minimum 30% of a student's overall grade, but were allowed to control exams for the remaining 70% of a student's grade.

This degree of standardization in science teaching is similar to standardization in military operations and one example is that of the military parade. Figure 28 shows a group of cadets at the Army's United States Miliary Academy as they march in formation during a parade. The individual groups contain a similar number of members to a science class section. While each group is led by a leader, that leader is following a prescribed plan. Each individual and group is standardized and in additional to being visually similar, they perform standardized actions.

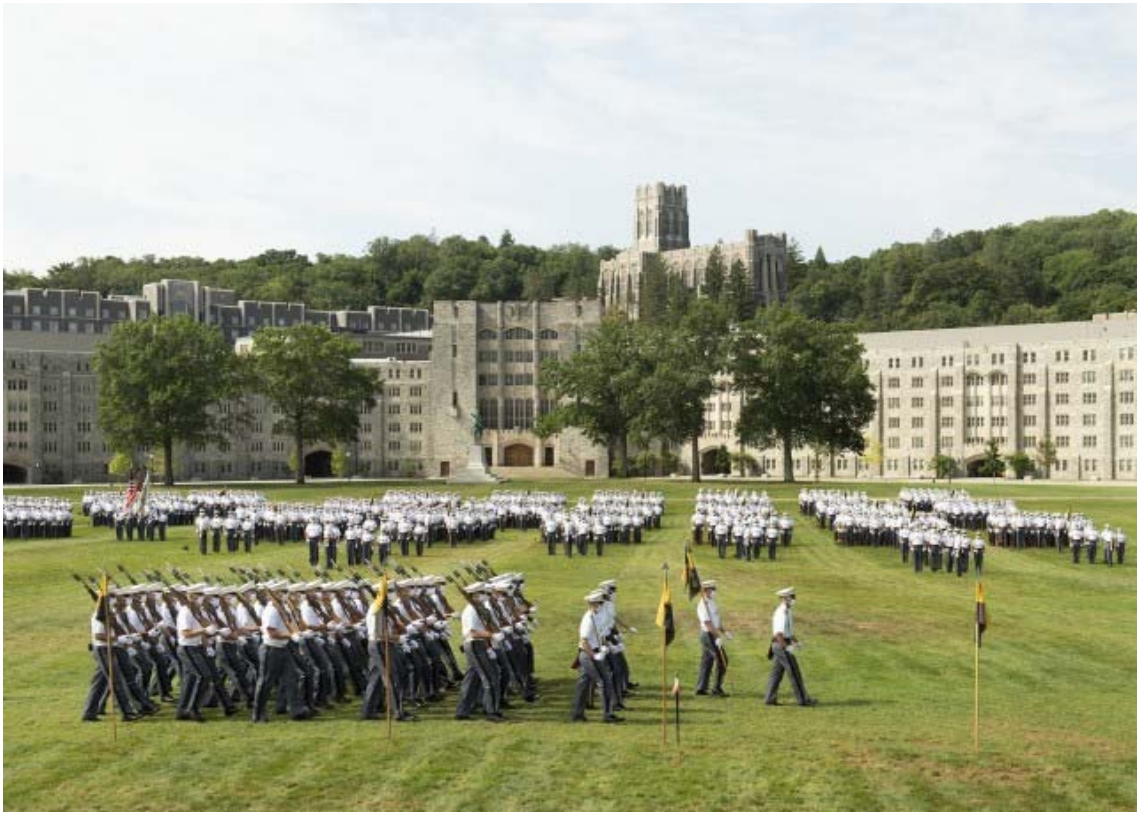


Figure 28: Companies of USMA cadets conducting a military parade. In this operation, groups assemble and march across the field in a pass and review. Group sizes and organization similar to academic class sizes and organization. Groups appear very similar and all groups march "in step" with each other. Photo used with permission of U.S. Army, Photo by John Pellino/USMA (Garcia, 2020)

As can be seen in Figure 28, standardization of a task as simple as walking is to a degree in the military such that tracks of foot step are visible in the field that is being crossed. Military parades are an infantry practice held over from the 1900's. Their utility corresponded to a period in military history when moving troops into a battlefield and quickly massing them against an enemy provided a tactical advantage (Mercur, 1888). Soldiers' movements were as uniform as possible and individuals marched in time with marching drums.

As a point of possible irony, the parade field in Figure 28 is physically located adjacent to the academic buildings that contain the science departments for the US Army's service academy. Cadets are a part of standardization on the parade field next to where they are a part of standardization in the classroom. But while many elements of science teaching such as the organization, content, pace, and assessment are standardized, the last section explores some non-standardized teaching practices

reported by instructors. In summary, if instructors could not control the "what" and "when" of their teaching, they reported being able to control the "how" of their teaching practice.

Standardizing teachers: past and present

This section further explores the standardization of teaching practices and beliefs not yet covered. It begins with a historical account from the oldest US military service academy followed by current practices and beliefs of science instructors.

The past: "In step" in the classroom

One old historical account of standardized teaching practice was reported. This two-part account was provided from an instructor in the Army and described their discovery of 70-year-old lesson plans at the 200-year-old service academy.

> *"When we moved into this building, we uncovered a lot of stuff from the 30s and 40s in the closets. And somebody pulled one off the shelf, it was lesson plans for physics from 1947, and it was a leather abound thing and it just opened to the page on fluid dynamics. And on the front it says "class demonstration: have cadets take out and light a cigarette". I thought "Oh, my gosh, it's the same thing". I was just teaching that class [on laminar flow] and I had just put up a picture of a cigarette. We're doing exactly the same things now as we were doing immediately after World War II, introductory physics has barely changed." – US Army, civil servant instructor*

This instructor proposed the fact that while science itself may be revisionary (Lederman, 2013), much of the basic science has not changed significantly in a sometime. Not only did they describe the 70-year-old lesson plans as containing the same topics they were teaching, but also containing the same in class demonstrations currently being used. The instructor continued with their account to describe how teaching practices and beliefs had reportedly changed.

> *"So, a lot has as probably stayed the same. But so much is probably different. And a lot of the old guard here will talk about how it used to be. How in the core course you could walk down the hall and just hear the lectures going and they were all lock-step, by the clock, by the beat, and if someone was off there was something wrong with that class. That's not true anymore, because education theory says that that's bad." – US Army, civil servant instructor*

This instructor reports an account from the "old guard". In this account, all course sections apparently used a lecture format and that these lectures were very standardized. The description of lectures as "lock-step" and "by the beat" portrays an image similar to the military members in Figure 28 marching across a parade field stepping in time with a drum beat. The instructor also reported the previously belief in the department that to be figuratively "out-of-step" with this teaching practice was

"wrong". The author participated in many military parades during their military career, some even on the very field in Figure 28, and noted the "out-of-step" individual located 3rd row from the rear of the formation in the foreground. In this operation, being out of step is certainly "wrong" and out-of-step members will be policed by other members in the formation. From the teaching account, the instructor shifts to point out that this belief no longer represents current teaching practices and that opposite beliefs about standardization are now held. It is these current teacher practices and beliefs about standardization that will now be presented.

The present: transitioning to "out-of-step"

In turning to current practices, there were no current reports of teaching practices standardized to the level of the old-guard historical account. But standardization was not a completely abandoned practice. There were several instructors that supported 1 account of a recent relaxation from standardization that occurred approximately 12 months prior to field work. One instructor, now in their second year of teaching, provided their account of practices before and after a directed change in teaching practice.

> *"Inquiry based learning; it was basically prescribed as the pedagogy to use my first year. It was like 'you will use this method'. Now, it's kind of like, 'do what you think is best'." -Army instructor*

This quote accompanied the discussion on hierarchy in the department and the direction to use a prescribed textbook presented in section 5.2.1. In addition to being assigned a specific text book, the group of core course instructors were directed to use a particular standardized POGIL teaching method in the classroom. The instructor reported that practices had changed recently and instructors were allowed personal choice of teaching method when the department head decided change both the textbook and standardized teaching practice. While not reportedly occurring during fieldwork, teaching method standardization was a practice familiar to some "new-guard" instructors.

Non-standardization of teaching was the most commonly reported practice across all departments and instructors reported a practice of teaching science in the manner that seemed best to them. Here are several accounts from both leaders and instructors across all services.

> *"With respect to those lesson objectives, those are the things that must be covered, how you teach them, ultimately is the instructor's discretion." – US Army, active-duty military instructor and department leader*

"You're kind of constrained in the content, but the method you use to deliver it, I think, is pretty wide open. And if you go from classroom to classroom, and I try to observe everybody in the course, you do see a mix of techniques" – US Air Force, active-duty military instructor and course director

"So, we embrace a lot of the ideas of active learning but have a pretty wide variance in terms of how the 45 of us implement those ideas. Everywhere from straight lecturing to totally POGILized chemistry classrooms" – US Navy, civil-servant instructor and department leader

"The idea in the core course is, 'here are the set of topics that are [to be] covered today, however it is you want to cover them, cover them'." – US Army, civil servant instructor

These accounts across all departments report a similar practice of standardizing the content, but not standardizing teaching practice. The first two accounts from those in leadership positions support the belief in non-standardized teaching practice. The next two accounts from instructors also reflected the belief that they were not required to standardize their teaching practices. This teaching belief and practice represented the vast majority of other instructor accounts collected. In connecting these data to answering the research questions, the simple answer is that instructors do not seem to believe that their teaching practices in the classroom are standardized.

But this instructor belief might need more discussion as it relates to actual practice. In combining discussion presented in section 5.2.1 on hierarchy in the department with discussion on old-guard and even more recent new-guard accounts of standardization practices, it is difficult to claim that instructors' beliefs about standardization translate into instructor practices. The section on hierarchy presented that Department leaders certainly held the influence to shape the teaching practices of their departments with the board work example from the Air Force and textbook change from the Army. In the Army account, curriculum standardization of the textbook was connected to a standardized classroom practice of POGIL. Furthermore, since core courses maintained a high level of standardization in their administration and curriculum, perhaps these combined elements suggest that while instructors believe they are free to practice however they want there are still pressures from these elements that drive them to standardize their teaching practices. Perhaps this is an intersection of hierarchy, standardization, and the idea of personal freedom where members from different groups might believe different levels of freedom exist. A military member, accustomed to surrendering aspects of their personal freedom like dress and appearance, where they live, what they do, might believe they are "very free" in the same setting where a non-military individual might believe the

same sacrifices to be elements of hierarchy or standardization that invalidates their freedom to choose teaching practices.

This question, and the exact nature of instructor beliefs and how they relate to their practices, might not every be fully known, if even possible. As this question is beyond the scope of the current research questions and methodology it will be saved for other research efforts. In refocusing on answering the current research questions, teaching as a military operation will shift from a discussion on standardization to the idea of camaraderie between instructors as the topic of the next section.

5.2.3 Camaraderie and its influence on teachers' beliefs and practices

This section presents data for the idea that just as camaraderie develops in military operations, it also developed in the teaching communities of science departments at the US military service academies and it serves to influence teachers' beliefs and practices, the second research question. It begins with a description of camaraderie in active-duty military units followed by beliefs expressed by science instructors. It moves to a discussion camaraderie as a teaching practice through mutual assistance between instructors. Aspects of instructor mutual assistance include experience sharing and the sharing academic material.

Camaraderie as a military concept and beliefs of camaraderie among science teachers

Camaraderie, or the "mutual trust and friendship among people who spend a lot of time together" (Lexico, n.d.), is a quality that often develops in military culture (Burk, 1999). This seems understandable as mutual trust is a vital aspect of the profession of arms. A profession in where one might be responsible for the lives of others, and in turn be required to place one's life in another's care. Military service also often requires members to spend large amounts of time together and separated from their families during times in their careers (Riviere & Merrill, 2011). Some of these times included their initial training or "boot-camp" or operational deployments during military campaigns or exercises. The military is not the only place that camaraderie develops and it is likely present in a number of other groups such as sports teams, classmates, and co-workers. Camaraderie in

university teacher learning communities has even been the subject of professional development in educational research (Thomson & Barrie, 2021).

Many elements of a science teacher's experience at a US military service academy resembled those of the regular military. Section 5.1.2 described how incoming new instructors went through a type of teacher training that could in some ways similar to a "boot-camp". Sections 5.2.1 and 5.2.2 described how instructors were placed into a hierarchy and certain elements of their practices were standardized. This section will present instructor beliefs on belonging and inclusion that could be identified as camaraderie.

Camaraderie as a belief or practice to be investigated was not identified during pilot interviews. Accordingly, no questions on the interview protocol were developed to investigate instructor camaraderie or instructors' sense of community in their department. But during analysis of interview data, teacher beliefs that could be described as camaraderie were identified as explanations for various reported teacher practices. One particular instructor belief seemed to capture the concept of camaraderie and connect it to a number of teacher practices. The following is the instructor's account.

> *"I feel that part of this learning community is really special. We're able to lean on each other and deal with mutual problems and mutual successes. That part is really nice about our department." – US Air Force, civil-servant instructor*

This instructor believed that they were part of a special learning community, identified as their department elsewhere in the interview. They reported that their community was able to lean on each when facing mutual problems but also in turn shared in mutual successes. This appears to be a reasonable description of camaraderie in their department and shared some elements with military camaraderie. Ignoring the individual loss of soldiers, victories or defeats are shared by all combatants on a side.

During the initial interview analysis, the author failed to translate this belief into a follow up question on the survey such as "I share a lot of camaraderie with my fellow science teachers". Notwithstanding, Likert questions such as "I fit in well in my department" were employed to explore the various concepts that could be elements of camaraderie, see Appendix B: Survey. Table 23 presents these data.

Table 23: Data on Instructor Beliefs on fitting in in their department and institution.

	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
B8, I fit in well at my institution.	1	1.1%	4	4.3%	10	10.8%	34	36.6%	44	47.3%
B15, I fit in well in my department.	2	2.2%	7	7.5%	5	5.4%	25	26.9%	54	58.1%

Across all departments and services, 85% of instructors agreed with the belief that they fit in well in their department. And while held less strongly, almost the same number of instructors felt they fit in well in their institution. If "fitting in well" can be accepted as an element of camaraderie then a majority of science teachers hold the belief. In contrast to beliefs directly about a feeling of camaraderie, many more accounts of were collected on teacher practices that can be described as camaraderie.

Teachers practicing camaraderie: mutual assistance

As previously mentioned, no interview questions were designed to investigate the belief in camaraderie direct but a number of teacher practices of camaraderie were articulated during fieldwork. Practices of camaraderie were described as teachers providing mutual assistance in the group effort of teaching science. Some of these practices appeared to have no obvious personal benefit to the provider and mainly for group development. Mutual assistance was generally identified as developing teaching abilities through two types of practices: sharing teaching experiences in conversations and sharing academic materials for teaching.

Conversations about teaching typically presented as sharing stories about teaching experiences or scientific discussions. Accounts of these formal and informal conversations were reported across all services and departments. A few of the more formal discussion related to helping the group of core instructors as they prepared for presenting common material or laboratories. Here is an example from each service academy.

> *"We do that through a series of meetings, like brown bags, where we get together, and more or less just tell war stories. you know, 'I tried to teach this, this happened', Or, 'I've tried this, it worked really well'." – US Navy, civil-servant instructor*

> *"We still do the lab parties. So, before each lab, we try to get everybody together just to go through the lab common mistakes, expectations, that kind of thing" – US Air Force, active-duty military instructor*

> *"The core course would have a blend of new instructors, mid-term instructors and more senior instructors. And we have these chalk talks, were everyone gets together to talk about the next few lessons" – US Army, civil servant instructor*

In these examples instructors referred to the groups by various names such as "brown bags", "lab parties" or "chalk talks". These practices included the informal telling of teaching war-stories with commentary on what teaching practice worked, what didn't, common student learning pitfalls and discussions on upcoming events such as laboratories. It is likely the standardized curriculum and schedule previously described would influence the timeliness and utility of such discussions. Instructors reported creative names for their meetings. "Brown-bags" logically referrers to lunch time discussions and "lab parties" to discussions about labs, the last Army reference is a bit more cryptic. The Army term of "chalk" is not a reference to a chalk board, but rather an Army reference to a specific group of paratroopers, termed a "chalk", that will deploy from a single aircraft as a unit. The term has its historical origins in the World War II invasion of Normandy where glider aircraft were used to deliver groups of soldiers to the frontlines ("Rangers - Chalk," 2022). Individual aircraft were identified by numbers marked in chalk and teams of soldiers identified themselves by their "chalk" number. The Army instructor has used a term describing a group of soldiers about to enter a combat zone for a group of instructors about to enter the classroom.

Many instructor accounts described the practice of sharing experiences that would assisting new instructors, but there were a number of senior instructors who felt that the shared experiences also aided them in their teaching. Here is an account from a senior instructor on the abilities of new instructors.

> *"They know how to take technology nowadays, which I'm still trying to figure out. And they can just bang right through it and understand how to use it, and implement it. And they come up with the most creative ways to teach physics. And we share those creative ways very, very well. So that so that the other faculty can use it." – US Army, active-duty military instructor and department leader*

In this account the senior instructor was referring to junior instructors who were able to rapidly adapt their teaching styles to use technology in the classroom when teaching physics. These technologies and skills were also reportedly shared with the rest of the department faculty. Another

example of mutual assistance occurred not between senior and junior but between a civil servant instructor and a military instructor. In this example a civil servant was able to extract a teaching example from the experiences of an active-duty instructor with a submarine officer background.

> *"And that's why talking with officers is so huge. I went to a submarine officer and said, 'Look, I'm trying to describe the magnetic field and the students couldn't care at all about this, give me a naval reason.' He said, 'you have to degauss a submarine.' I'm like, 'what does that mean?' I didn't realize that subs pick up a magnetic field over time. That [field] becomes a magnetic signature which a plane flying overhead, with the correct device, can locate. So, you want to reverse that effect. So now having that example I can say to the students, 'this is why you should care about a magnetic field'. – US Navy, civil-servant instructor and department leader*

In this account a civil servant instructor was seeking to better motivate their students with a naval application of magnetic fields. An active-duty military instructor in their department was able to provide a reason for why the US Navy cares about magnetic fields and takes steps to degauss submarines. Presumably, this mutual assistance was utilized to increase student involvement in the teaching and learning of magnetic fields in class.

The presented excepts reflect a small portion of the interview accounts of mutual assistance through instructor discussions. Survey questions were designed to investigate teachers' beliefs and practices on these types of teacher discussions. An additional question was included to probe teachers' belief on how this practice influenced their science teaching. Table 24 presents these data.

Table 24: Teachers' reported beliefs and practices on sharing best practices, influence and seeking advice

	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
B14 Good science instructors meet with other instructors to share best practices.	0	0.0%	1	1.1%	4	4.3%	35	37.6%	53	57.0%
I8 My teaching has been influenced by informal discussion with other science instructors.	0	0.0%	3	3.2%	4	4.3%	34	36.6%	52	55.9%
I14 I regularly seek the advice of other instructors.	2	2.2%	8	8.7%	16	17.4%	39	42.4%	27	29.3%

From the data, almost 95% of instructors agreed that good science instructors should meet together to share best practices. On this topic there appears to be a high degree of consistency between interview and survey responses. 92% of respondents also agreed that these types of informal discussions had influenced their teaching. In comparison to other influences, discussions were the second strongest reported influence after teaching experience. But while almost 95% agreed that they should meet with other instructors only 71% agreed that they regularly did so. The difference does not seem very large but this is a possible case where a belief and associated practice did not perfectly align.

Experience sharing not occurred internal to a department, one case was reported as occurring between service academies. The Army, Navy, and Air Force chemistry departments met annually for an Inter-Academy Chemical Symposium (IACS) to exchange ideas. The location of this symposium rotated between the various academies.

> *"We share a lot at IACS about operational things like, 'how do you guys do this?' We share a lot of that idea passing, which is super helpful. And sometimes that revolves around things like assessments or meeting ACS guidelines. There're just a million things like that, it's more nuts and bolts kind of stuff" – US Navy, civil-servant instructor*

This chemistry instructor reported that this exchange was important avenue for passing idea topics such as assessment and meeting the American Chemical Society's accreditation requirements. A similar exchange of ideas between the physics departments was not investigated or reported. This section presented the practice of sharing experiences as a way of mutual assistance in science departments. These beliefs and practices support the military concept of camaraderie as a way science teaching as a military operation. In addition to the demonstration of camaraderie through mutual assistance and the practice of sharing experiences, teachers also practiced the sharing of teaching materials.

Just as instructors demonstrated camaraderie through mutual assistance with the sharing of experiences, they also practiced camaraderie by sharing teaching materials. This section will present accounts of the practice of sharing teaching materials from both the interviews and survey data. It presents an instance of where camaraderie broke down, and presents a belief that mutual support is

not only a good thing, but the expected thing. The section concludes with discussion of a possible origin of these sharing beliefs as an aspect of being a US government employee.

During the interviews, the practice of sharing teaching materials, such as lecture notes, power point slides, descriptions of demonstrations or any material useful in teaching, was widely reported across all departments in all services. Here are three examples.

> *"I make my lectures available. You can look at them. Sometimes things don't make sense because I've set up some little in class thing. And the person will come to me and say, 'Why doesn't this make sense?' And then I can tell them" – US Navy, civil-servant instructor*

> *"We have all of these resources, we pulled it together into a database that's accessible to instructors. We've got all this material; it's not really lesson dependence it's by topic and you pick and choose what you need." – US Army, active-duty military instructor*

> *"The collegial aspect of what we have at USAFA, I think is very different than from some of the other universities I've encountered through my advanced academic degrees, where the faculty is so willing to share all of their lesson content and their objectives. You develop as a team." – US Air Force, active-duty military instructor and department leader*

These three accounts illustrate different aspects of the practice of sharing teaching materials. Sharing was reported in a peer-to-peer setting in the first account. This instructor commented that sometimes additional information was needed because it wasn't captured in the lecture notes, but that this instructor also shared those insights. In the second account, sharing was practiced in a department as the development of databases for use by all instructors. In these databases or "shared drives" from other accounts, instructors could post or utilize any teaching materials.

The last account from an Air Force instructor expresses their beliefs about their institutional community and how they related to the practice of sharing teaching materials. They believed the collegial aspect of their institution led to an environment where instructors practiced sharing their materials. They believed this resulted in the group developing as a team. This team development description could suggest the concept camaraderie. This instructor additionally reported that this collegial attitude was different from other tertiary education institutions they had been a part of. While this anecdotal account might be valid, this study did not examine any non-military schools and the claim cannot be supported with any additional evidence. But the idea of comparing aspects of military schools to non-military schools would be an interesting future study.

In addition to the interviews, the beliefs and practices of sharing material were widely reported in the instructor survey. Survey questions were designed to investigate both teachers' beliefs towards both sharing and utilizing teaching materials. An additional question probed instructors' practice of utilizing teaching materials developed by others.

	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree	
	Count	%	Count	%	Count	%	Count	%	Count	%
B7 Instructors with good teaching materials should share them with fellow instructors.	0	0.0%	0	0.0%	2	2.2%	26	28.3%	64	69.6%
B1 Instructors should feel comfortable utilizing teaching materials developed by other instructors.	1	1.1%	6	6.5%	13	14.0%	23	24.7%	50	53.8%
I12 Other instructors' teaching materials have been invaluable to me as an instructor.	3	3.2%	8	8.6%	13	14.0%	22	23.7%	47	50.5%

In almost 98% agreeance, teachers overwhelmingly agreed with the belief that teachers with good teaching materials should share them. This strong belief corroborates with the interview findings. It also supports the strong instructor belief in sharing experiences through discussions presented in the previous section. If camaraderie has elements of mutual assistance through sharing, then these data suggest camaraderie is a widely held belief and practice. Still strong but less overwhelmingly, 78% of teachers believed that instructors should feel comfortable using those shared resources. It is unknown as the exact reason for the decrease in support of this belief but perhaps some instructors felt this might not apply in all teaching circumstances. Perhaps instructors do not support such a practice if it is performed by senior instructors who are simply unwilling to develop their own teaching materials. In shifting from beliefs to practices, almost 75% of instructors agreed that using others' resources had been invaluable to them as an instructor. This response also correlated well with interview accounts of the practice. Sharing materials appears to be a practice that couples well with the practice of On-the-Job training described in section 5.1.2. With the higher turnover rate of

active-duty science instructors, sharing material would allow military academies to rapidly educate new instructs in teaching and deploy them to the "battlefield" of the classroom.

While nearly all accounts reflected a willingness to share, one account stood out when it illustrated the opposite. This account was provided by an Army instructor working as a course director. It described their attempt to obtain a syllabus from a different course they were not a part of. The other course director was a member of the same department but offered resistance to the request.

> *"I was explaining how I'm trying to overlay lesson objectives between life sciences and chemistry, because chemistry 101 is a feeder course for [life sciences] 275. I wanted to see how the lesson objectives lined up to maybe better align the two. And when I went to life sciences to do that, they said "why do you want our lesson objectives? What are you trying to do with that?" If we're in same department the answer should be 'Roger, here you go'. So, it's just a disconnect in our department," – US Air Force, active-duty military instructor*

This instructor expressed disappointment in lack of immediate and unquestioned assistance by a fellow department member. The instructor expected a response of "roger, here you go", a response suggesting the belief that sharing material should be the norm and not questioned or resisted. The "disconnect" is framed as occurring between the cadre of life sciences instructors and the chemistry instructors. Instructors of chemistry and biology are both in the same department at the Army's academy while the Air Force's academy has a separate department for each. There were no accounts of either sharing, or reluctance to share collected from the Air Force Academy. The Naval academy did not offer life sciences as a field of study so there were no accounts to examine there. Perhaps the willingness to share only exists within scientific disciplines as opposed to science departments

An idea for the origins of this belief will be presented. Camaraderie through mutual assistance might originate at the military service academies or it might be an aspect of being involved in US government service. Employment in the military or government is considered a public service after all. Mutual support and camaraderie could be elements involved with a profession described as service. The author makes no claims that those in government service are selfless in all their actions. Rather, in government service accomplishments become property of government. A solider who fights and wins on the battlefield is not compensated with a portion of the battlefield, unique compensation if any for the soldier might take the form of a medal or a position of increased authority. This idea extends to those involved in science and technology. The author has

approximately 17 years of experiences working in various academic and research and development organizations across the US Air Force. From the author's perspective there is general acceptance among scientists and engineers that any intellectual property developed individual becomes property of the US government. This belief is likely reenforced by a number of US laws that enforce it. Here is an example of one such law as it pertains to government employees and their inventions. Quoting from US Executive Order 10096.

> *(a) The Government shall obtain the entire right, title and interest in and to all inventions made by any Government employee (1) during working hours, or (2) with a contribution by the Government of facilities, equipment, materials, funds, or information, or of time or services of other Government employees on official duty, or (3) which bear a direct relation to or are made in consequence of the official duties of the inventor.* (Exec. Order 10096, 1950)

This excerpt addresses only inventions, but similar laws extend to almost all forms of intellectual property developed by US government employees. While the idea was never expressed by any instructor, perhaps instructors believe in sharing due to an underlying belief that all lesson plans or teaching materials developed by an instructor are, in reality, already property of the US government.

In summary, this section presented the concept of camaraderie in the military and how it was observed between science teachers at the US military service academies. The concept was used as a framework for understanding instructor beliefs and practices on providing mutual assistance through the sharing of experiences and teaching materials. It was part of a larger claim that science teaching at the military academies is conducted in similar ways to a military operation.

5.3 Chapter summary

In summary, this chapter made contributions to answering the research question exploring the influences on science teachers' beliefs and practices. Section 5.1 presents findings on how the selection and training of new instructors followed a similar pattern in other parts of the US military. New instructors would learn to teach on the job and departments had to account for a high turnover rate of their instructors. Section 5.2 presented findings on how hierarchy, standardization, and camaraderie might influence instructor beliefs and practices. Military hierarchy was described in both regular military units and at military schools. Findings were presented of how department leaders used

their position and power to shape both the beliefs and teaching practices of their instructors. Hierarchy was also explored as to how it might affect learning in the classroom. It was found that a hierarchal relationship between student and instructor might hinder a student's willingness to ask questions and as a result their science learning. Some instructors also took effort to change the perceptions of hierarchy in the classroom to increase learning or gain respect of students. Instructors were described as having beliefs about their identity with one view of the classroom commander presented. Findings also presented how science departments standardized their curriculum. Multiple small classes of students each with their own instructor would be learning the same scientific content at roughly the same rate and would be evaluated with the same assessment tools. A culture of camaraderie among instructors was presented through evidence. Teachers were documented meeting together to share teaching materials and for the purpose of mentorship. The final findings chapter explores how the previously documented beliefs and practices might vary between different military groups.

6 FINDINGS 3: EXPLORING VARIANCE IN PRACTICES AND BELIEFS

Introduction to the chapter

Chapter 4 focused on presenting evidence to address the first research question on identifying the pedagogic beliefs and practices of science instructors at the US service academies. Chapter 5 expanded this discussion with findings on the second research question of what are the sources of influences on the pedagogic beliefs and practices. Several findings in chapters 4 and 5 required qualifying statements that the pedagogic practice or belief being described varied and was not held by all student's instructors. This chapter seeks to add richness to the discussion on pedagogic beliefs and practices in military settings by answering the third research question investigating how teaching beliefs and practices varied across different military settings.

Section 6.1 presents a framework for the findings of the chapter and a tentative idea of variance based on teacher identity. Section 6.2 presents variances found between the military and civil servants, along with findings from their various subgroups. Section 6.3 presents variance findings between the various military branches, the academic departments, and some minor subgroups. Section 6.5 presents a summary of the findings.

6.1 Findings overview: identifying groups and themes

The findings that answer the research question on variance proved to be complicated and required a degree of nuance in their presentation. Immediate presentation of variance data could lead to myopic discussion so this section will present a framework for variance. Section 6.1.1 presents some of the underlying assumptions involved with the findings, such as how groups of instructors were defined based on elements of instructor identity (Avraamidou, 2014; Beijaard et al., 2004, 2000; Gee, 2000; Izadinia, 2013; Mansour, 2008)). Section 6.1.2 presents a tentative explanation for variance in which the pedagogic beliefs and practice of groups can be placed. This tentative explanation for variance serves as scaffolding in which supporting data will be woven into in as the chapter proceeds. Section 6.1.3 concludes the overview with as a brief review of the statistical methods utilized to determine variance.

6.1.1 **Assumptions: groups and theoretical underpinnings**

The first aspect of answering the research question on group variances is defining how groups of science instructors were developed. Methods section 3.3 described how ideas from literature, ideas from the author's prior knowledge within the military, and interview data collected during field work were all used to develop a number of demographic questions for the survey portion of the study. These demographic questions explored the science instructors' involvement in other military settings and aspects of their professional development as instructors. The following military and professional development factors were explored. Was the instructor and active-duty member or a civil servant? If the instructor was military, what military career field? If a civil servant, did they have previous military experience? If the instructor had military service, what service were they in and were they a service academy graduate? What levels of education did the instructor hold and in what discipline? How much teaching experience did the instructor have? How old was the instructor and what was there gender?

Grouping instructors based on a singular demographic and ignoring sub-groups often conflated variance findings. As an example, one interviewed instructor could be defined by their inclusion in a number of groups such as; military officer, naval officer, physics instructor, an inexperienced teacher, MS degree holder, a combat role officer, a service academy graduate, or as a male. By considering a more complex view of groups and individual teachers based on their professional identity, a more holistic approach to exploring group variance was found. This complex view is illustrated in section 6.2 where findings on variance between military and civil servant status mask a number of additional findings in their respective subgroups. Professional, or teacher, identity was presented in section 2.2.1 but the main points will be acknowledged. Gee defined identity as "being recognized as a certain 'kind of person,' in a given context" (Gee, 2000, p. 99). Accordingly, instructors' membership in various groups was based on the 'kind of person' they were as collected from the data. Avraamidou, in building from Beijaard et al. (Beijaard et al., 2004), also added that teacher identity is 1) socially constructed and constituted 2) dynamic and fluid with constant revision and 3) complex and multifaceted containing various interrelated sub-identities (Avraamidou, 2014, p.

164). Combing complex group findings with the complex nature of instructor identity resulted in a more holistic answer to question concerning group variance. The variance findings seemed best explained by a tentative explanation for variance including a spectrum of pedagogic beliefs and practice and a dynamic nature.

6.1.2 A tentative explanation of variance: Militaryness

The unique contribution of this study is centered upon its setting within the US military, a rarely examined location for higher education science teachers. Combining this with the findings, a tentative explanation of variance was developed contrasting a very military approach to pedagogic beliefs and practices with a less military approach. Individuals and groups could both be placed at various locations along the spectrum for various pedagogic beliefs and practices. Figure 29 was developed from the previous finds as an overview of the two contrasting teachers and their teacher identity, one end has been titled "The Classroom Commander" and the other "The traditional Chem Prof".

Spectrum end titles	The "Classroom Commander"	The traditional "Chem Prof"
	Dynamic: Military instructors drift to right →	
Summary of beliefs, practices and influences identified	focused on preparing officers with science *and more* tailoring scientific material to military students Favors Hierarchy and structure More likely to utilize camaraderie	focused on teaching science scientific material applicable to any student Favors academic freedom More likely to be self-sufficient
Summary of general trends in groups by identity	Active-duty Military Master's Degree Younger in age Less teaching Experience Army and Air Force	Civil Servant instructor Doctorates Degree Older in age More teaching experience Navy

Figure 29: A tentative explanation of variance as an aspect of instructor identity

The military approach has been presented in findings chapters 4 and 5. The title of "classroom commander" was sourced from an instructor quote in section 5.2.1. The term has been adapted from its original usage to describe a hypothetical instructor who champions the most military centric pedagogic beliefs and practices. These military pedagogic beliefs and practices include those findings such as focusing on preparing officers (section 4.1), adapting science content for a military audience

(section 4.2), teaching science as a military operation through the concepts of hierarchy, standardization, and camaraderie (section 5.2) and professional development (section 5.1).

The contrasting approach presented utilizes a *less* military, but not a non-military, approach to pedagogic beliefs and practices. This end of the spectrum has been titled the "traditional chem prof." This title was sourced from a civil servant instructor's response of "I think our students know their chemistry better" presented in section 3.2.3. This hypothetical instructor embraces the minimum amount military focused pedagogic beliefs and practices and a greater focus on the traditional practice of teaching science. While this tentative explanation for variance might appear to represent a professor in a traditional higher education setting who has no military connection, non-military schools and instructors were not studied in this research effort and this claim cannot be made. This description could be more accurate of a civil servant instructor who teaches science in a military setting and is employed by the US Department of Defense yet is less supportive of many military approaches of doing things. It is possible that if this hypothetical instructor were extracted from their military setting and placed in a non-military setting that their pedagogic beliefs and approaches might be comparatively considered to be military in nature.

The tentative explanation for variance presented in Figure 29 is a preliminary answer to the research question on group variance and the following sections of this chapter will present data supporting it. Some general trends have been added to Figure 29 suggesting how certain groups or aspects of teacher identity might generally be more associated with one end of the spectrum or the other. Additionally, data suggested a dynamic element to the tentative explanation for variance in Figure 29. This will be illustrated when examining various sub-groups of instructors, such as inexperienced and experienced military instructors. In these groups there appeared to be in a gradual state of drift in pedagogic belief and practice towards the Chem Prof side of the spectrum. This dynamic element agreed with Avraamidou's description of identity as dynamic, fluid, and under constant revision (Avraamidou, 2014). A final element prior to presentation of quantitative data is a short review of the statistical methods employed in developing the findings.

6.1.3 **A review of statistical methods to investigating variance**

The previous section described a tentative explanation for variance. This section serves as a short review of how variance was investigated with statistical methods. A full description on survey data generation and quantitative data analysis was provided in section 3.3 but some important elements will be presented. The survey was developed using the qualitative findings from the interviews and instructors were asked 15 questions on their pedagogic beliefs, 16 questions on their pedagogic practices, and 14 questions on influences to their teaching (section 3.3.2). Appendix B includes a table of these 45 measures and which section they were described in. As covered in section 3.3.3, Likert style questions (Likert, 1932) produced non-parametric ordinal data and were analyzed with non-parametric tests such as the Mann-Whitney test (Mann & Whitney, 1947; Wilcoxon, 1947) and Kruskal-Wallis test (Kruskal & Wallis, 1952). These tests are similar to the independent two-sample t-test and one-way analysis of variance tests but utilize rank order data to generate mean ranks instead of actual response means (Pearson, 1895; Student, 1908).

For groups with only two categories, Mann-Whitney analysis was conducted in SPSS (Field, 2013, p. 223) and the results provided a Mann-Whitney test statist (U), a standardized test static (*z*-score), and the significance (asymptotic, 2-sided test, ρ). The z-score was used to calculate an effect size (r) with the following equation where N is the total number of participants (Fritz et al., 2012; Rosenthal, 1991).

$$r = \frac{z}{\sqrt{N}}$$

Cohen (J. Cohen, 1988) suggests some effect sizes for r of:

r	Effect size
0.10 to 0.24	small effect
0.24 to 0.37	medium effect
0.37+	large effect

In this chapter, only items from the survey with meaningful significance ($\rho<0.05$) and at least a medium effect size ($r>0.24$) have been reported. For groups with three or more categories, Kruskal-

Wallis tests (Kruskal & Wallis, 1952) were conducted in SPSS (Field, 2013, p. 236) provided a Kruskal-Wallis test statist (H), and an adjusted significance (2-sided test, ρ). Unlike the Mann-Whitney tests, Kruskal-Wallis tests that indicated significance required follow-up pairwise analysis (Field, 2013, p. 243). This pairwise analysis was similar to the Mann-Whitney analysis and provided standardized test statics (*z*-scores), and adjusted significance (asymptotic, 2-sided test, ρ) but could not provide meaningful data for effect sizes (r).

In summary, this section introduced a tentative model to explain variance in military groups and a review of instructor identity and quantitative methods. The following section will present the data on variance between difference groups of science instructors at the US military service academies, beginning with the differences between military officers and civil servants.

Exploring Entangled Groups

In order to addresses the final research question of "Do the teaching beliefs, practices, and influences vary between groups?" it was necessary to first define the various groups. Initially, demographics questions on the survey were used to define groups by aspects of their identity, with some identities presumably tied to a setting. These groups are shown in Table 25.

Table 25: Exploring Groups

Binary and Larger Groups explored		
Group size	Binary Groups	Groups of 3+ (# of groups)
Statistical Test	Mann-Whitney	Kruskal-Wallis
Groups explored	Male versus Female	Branch of Service (3)
	PhD versus MS	Branch of Service (3, civ only)
	Active-Duty Military versus Civil Servant	Branch of Service (3, mil only)
	Military Background or Not (All)	Science Departments (7)
	Military Background or Not (Civil Servants only)	Science Departments (7, civ only)
	Service Academy Graduate or Not (All)	Science Departments (7, mil only)
	Service Academy Graduate or Not (w/ military background)	Experience (3)
	Service Academy Graduate or Not (military only)	Age (8)
	Chemistry and Biology versus Physics	Military occupation (3, mil background only)
	Chemistry versus Physics	

During analysis it was immediately discovered that certain groups in Table 25 had a number of significant variances with other groupings in the table. As an example, the next table shows

findings variances of both PhD versus Master's degree holders groups and civil servant versus active-duty instructors groups.

Table 26: Mil/Civ or PhD/MS?

	Mann-Whitney Tests			
	PhD versus MS		Mil/Civ	
Survey Question	significance (p)	effect size	significance (p)	effect size
B10: I consider myself an experienced science instructor in my discipline.	<0.001	0.5693	**<0.001**	**0.6071**
P4: I prepare non-science related content for presentation in class (such as "life lessons").	**<0.001**	**0.3757**	<0.001	0.3518
P5: I utilize opportunities to discuss character development if they present themselves in class.	**<0.001**	**0.4188**	0.001	0.3356
I5: My teaching has been influenced by continuing formal teacher training programs offered at my school.	<0.001	0.3745	n/a	n/a
I6: My teaching has been influenced by department training provided on arrival.	0.002	0.3164	**<0.001**	**0.3491**
I7: My teaching has been influenced by continuing department training.	n/a	n/a	**<0.001**	**0.3473**
I12: Other instructors' teaching materials have been invaluable to me as an instructor.	n/a	n/a	0.001	0.3355

Of the 45 measures, Table 26 show the only ones that were both significant ($p<0.05$) and had at least a medium effect size ($r>0.3$). The table shows that 4 the 7 measures (B10, P4, P5, I6) have significant differences between both groups. In examining the two groups descriptively, Table 27 shows that there is large overlap in similarity between these two ways of making groups.

Table 27: Crosstabulation of Military status and Degree Held

What is your highest degree held? (count)			
	Master's degree	Doctoral degree	Total
Active-Duty Military	34	19	53
Non-Active-duty	1	47	48
Total	35	66	101

Nearly all of the civil servants (97%) held a doctoral degree while 71% of active-duty military instructors held a master's degree. When grouping instructors by degree held, effectively all the civilians were included in one group and most of the active-duty military in the other. Using a

number of crosstabulation tables, it was possible to see that a number ways of making groups had large overlaps. In addition to having a high percent of doctoral degrees, civil servants also had more teaching experience in general, Figure 30, and were older than their active-duty military counterparts, Figure 31.

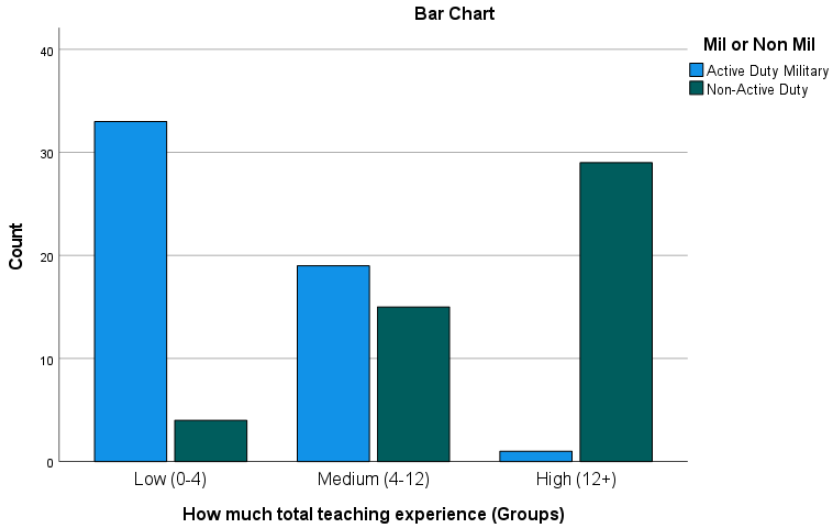


Figure 30: Teacher experience of Military and Civil Servants

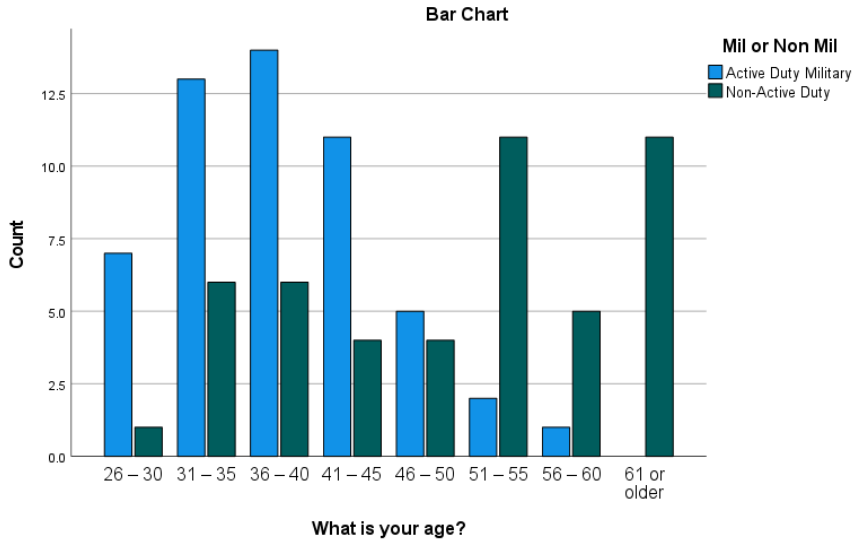


Figure 31: Age of Civil Servants and Active-duty military instructors compared

To order to identify meaningful group variances, data were further subdivided to explore if aspects still varied within sub groups. For example, Mann-Whitney tests were run on only military members to identify if holding a doctoral degree or a master's degree resulted in any variance

between teacher practices, beliefs and influences. This data has been updated to Table 26 and presented in Table 28.

Table 28: Degree versus Military or Civilian

	Mann-Whitney					
	PhD versus MS		Mil/Civ		PhD versus MS (Mil Only)	
Survey Question	significance (p)	effect size	significance (p)	effect size	significance (p)	effect size
B10: I consider myself an experienced science instructor in my discipline.	<0.001	0.5693	**<0.001**	**0.6071**	**0.008**	0.38
P4: I prepare non-science related content for presentation in class (such as "life lessons").	**<0.001**	**0.3757**	<0.001	0.3518	**0.011**	0.36
P5: I utilize opportunities to discuss character development if they present themselves in class.	**<0.001**	**0.4188**	0.001	0.3356	**0.015**	0.34
I6: My teaching has been influenced by department training provided on arrival.	0.002	0.3164	**<0.001**	**0.3491**		

The additional examination suggests that the aspect of holding a doctoral degree is a valid way of grouping individuals. 3 of the 4 measures (B10, P4, P5) in Table 26 have significant variances even when only examining active-duty military instructors. But this doesn't rule out that another aspect such as teaching experience might be an even better way of grouping individuals. In this manner all groups were explored and disentangled as much as possible. Chapter 6 presents findings on how teaching practices, beliefs and influences varied by groups.

6.2 Variance between active-duty military and civil servants

One of the central contributions of this study is its placement within a military setting. That distinction drives the utility of beginning the presentation of variance findings on the variance between groups of active-duty military science instructors and the civil servant science instructors. Section 6.2.1 presents the general differences between the military and civil servant instructors. To add depth to these findings, data on military sub-groups will be explored in section 6.2.2 and data on subgroups of civil servants in section 6.2.3. The subgroups presented include scientific expertise, teaching experience, and other military experiences. Sub-groups based on military branch, academic department, and scientific discipline are presented separately in section 6.2.4.

6.2.1 **Military and civil servant variance**

Although all science instructors in this study were located within a military setting, not all science instructors, as said before, were active-duty military officers. Approximately half of the instructors were civil servants, and while employed by the US Department of Defense, these instructors typically did not have active-duty military experience. As said above, the data suggests that the non-military background of civil servants led to a number of variations in pedagogic beliefs and practices between the two groups. This finding was initially suggested in an example from section 5.2.1. That section presented an instructor account of a hierarchal department directed change in textbook and pedagogic practice. The instructor suggested that military instructors received the department direction differently than the civil servant instructors in the department based on their military background. This section explores that singular account and presents quantitative data exploring all of the pedagogic practices, beliefs and influences that varied between active-duty military and civil servant instructors.

Data for the variance on pedagogic practices, beliefs and influences between active-duty military and civil servants are presented in Table 29, and all tables in this chapter, present only the survey items with significant ($p<.05$) variance and at least a medium effect size ($r>.24$). Of the 45 survey items measured, 12 items had significant variance in response between active-duty military and civil servant instructors. These measures have been grouped into pedagogic beliefs and practices described as teaching science as a military operation (items I7, I6, I12, I11, I4 and Chapter 5), the aim of teaching as preparing future officers (items P4, P5, B13, B3 and Chapter 4) and other measures involving professional identity, experience, and identification with students (items B10, I1, B6) that have not been presented in previous chapters.

Table 29: Variance in Beliefs, Practices and Influences between Active-Duty Military and Civil Servants ($p<.05$, $r>.24$)

Survey Question	Active-duty Mean Rank	Civil Servant Mean Rank	Mann-Whitney Test Statistic **U**	Standardized Test Statistic **Z**	Significance **p** (2-sided test)	effect size **r**	Sample size **N**
I7: My teaching has been influenced by continuing department training.	55.7	37.3	664.00	-3.37	0.001	0.35	94
I6: My teaching has been influenced by department training provided on arrival.	54.8	36.7	637.50	-3.35	0.001	0.35	92
I12: Other instructors' teaching materials have been invaluable to me as an instructor.	55.1	38.1	697.50	-3.25	0.001	0.34	94
I11: I receive a lot of direction from my leadership on how to teach my science classes.	53.8	38.7	723.50	-2.77	0.006	0.29	93
I4: My teaching has been influenced by school wide training provided on arrival.	53.2	38.5	716.00	-2.69	0.007	0.28	92
P4: I prepare non-science related content for presentation in class (such as "life lessons").	55.9	37.9	678.50	-3.41	0.001	0.35	94
P5: I utilize opportunities to discuss character development if they present themselves in class.	55.6	38.8	722.00	-3.27	0.001	0.34	95
B13: Good instructors at US service academies should actively provide character or life skills lessons in addition to science content.	58.8	42.4	860.50	-2.99	0.003	0.30	101
B3: If an opportunity presents itself, it is acceptable to utilize class time to focus on character development which might require students to learn scientific content on their own time.	58.5	41.9	834.00	-2.99	0.003	0.30	100
B10: I consider myself an experienced science instructor in my discipline.	33.2	65.2	399.50	-5.98	<0.001	0.61	97
I1: My teaching has been influenced by personal teaching experience.	43.0	53.4	846.50	-2.52	0.012	0.26	94
B6: I identify well with my students.	57.2	43.2	898.00	-2.65	0.008	0.26	100

Instructor responses from the questions I7, I6, I12, I11, I4 support the finding that active-duty military instructors were more likely to have been influenced by concepts described as teaching science as a military operation (see Chapter 5). Military instructors reported a higher influence of initial and continued department training as well as school wide training on their teaching (items I7, I6, I4). These training concepts were presented in section 5.1.2 as boot camp style teacher education

and structured instructional processes within the military. Military members also reported a greater influence of leadership direction on their teaching practice (item I11), supporting the idea that military are more influenced by their department hierarchy and the instructor's account from section 5.2.1. Lastly, military instructors reported a greater influence of camaraderie (section 5.2) in utilizing other instructors' teaching materials in their own teaching (item I12).

Data from the second set of questions (P4, P5, B13, B3) support a claim that active-duty military instructors embrace a both an increased belief in and practice of activities demonstrating the aim of teaching as preparing officers for military service (section 4.1). Military instructors also reported stronger beliefs in and an increased practice of bringing non-science related content, such as life lessons or character development, into the science classroom.

Data from the last group of questions (B10, I1, B6) are topics not covered in previous sections. Civil servants believe themselves both more experienced in science and more influenced by their own teaching experience than active-duty military instructors (items B10 and I1). These belief findings agree with the data indicating that civil servants typically had far more teaching experience that the military instructors. Conversely, military instructors believed they better identified with their students. This could be explained by a number of aspects such as both being active-duty military, and sharing a standardized uniform (section 5.2.2). Additionally, data revealed that military instructors were closer in age and scientific expertise to their students than civil servants.

In summary, these data are the first to support the Classroom Commander and Chem Prof variance model presented. These findings also reasonable agree with aspects of instructor identity. Active-duty military instructors have a professional identity that has been shaped by exposure to a traditional military environment to a much greater degree than many of the civil servant instructors. If instructor identity is socially constructed and dynamic (Avraamidou, 2014) then military instructors will have constructed military focused concepts of identity during their regular military service. Additionally, on identity, Wenger states that "these relationships change. We move from community to community. In doing so, we carry a bit of each as we go around. Our identities are not something we can turn on and off" (E. Wenger, 2010, p. 239). This suggests that military instructors will bring their professional identity as a military officer into each new environment they encounter, including

academic environments. But teacher identities have been described as dynamic and these professional identities of the military instructors might change over time. One way to explore this dynamic element and other elements of military setting is by exploring the data on various military subgroups.

6.2.2 Military subgroup variance

Active-duty military science instructors, as suggested by Avraamidou, could be subdivided into a number of sub-groups (Avraamidou, 2014). The subgroups explored in this section were based on instructor experiences. Subgroups in this section explore variance based on scientific expertise (such as a PhD or MS Degree, teaching experience, experience as a service academy graduate, and professional military experience.

Scientific Expertise (PhD/MS) subgroup

Data in this section develops the variance model's claim in that that pedagogic beliefs and practices of active-duty military instructors were in a general drift towards the Chem Prof end of the spectrum. As longitudinal data was outside the scope of the study, this claim was developed by examining data from both experienced and inexperienced instructors. Experienced in this section was defined by level of scientific training and measured by the type of advanced degree held by the instructor.

Experienced could also be defined by years of teaching experience but data suggested strong connections between advanced degree and teaching experience. This was likely a result of data presented in section 5.1.1 on officer assignments that were controlled by a centralized personnel office. In a typical officer career progression involving teaching assignments, an officer was sent to obtain a master's degree immediately prior to their first 3 years teaching assignment. Officers identified for an additional teaching assignment would typically obtaining a PhD prior to beginning those duties. So PhD/MS status yielded similar results to those with less than 4 years of teaching experience as novices (Haverly et al., 2020) and those with more as experience instructors.

Table 30 contains the significant items of variance between active-duty instructors holding a MS degree compared to those hold a PhD degree. 7 items of variation were identified between the two subgroups of military.

Table 30: Significant Variance in Beliefs, Practices and Influences between Active-Duty Military with MS degrees or PhDs

Survey Question	MS (Active-Duty) Mean Rank	PhD (Active-duty) Mean Rank	Mann-Whitney Test Statistic **U**	Standardized Test Statistic **Z**	Significance p (2-sided test)	effect size **r**	Sample size **N**
I5: My teaching has been influenced by continuing formal teacher training programs offered at my school.	30.47	17.06	137.00	-3.173	0.002	0.44	51
P4: I prepare non-science related content for presentation in class (such as "life lessons").	29.00	18.71	165.00	-2.549	0.011	0.36	50
P5: I utilize opportunities to discuss character development if they present themselves in class.	30.01	19.86	186.50	-2.443	0.015	0.34	52
P8: I try to make my lectures more engaging by asking a lot of questions during class.	29.49	22.55	238.50	-2.032	0.042	0.28	53
P14: I conduct physical demonstrations during class instruction.	30.22	19.47	179.50	-2.533	0.011	0.35	52
B5: Military instructors are better received by military students than civilian instructors.	29.06	19.88	185.00	-2.190	0.028	0.31	51
B10: I consider myself an experienced science instructor in my discipline.	21.35	32.53	143.50	-2.664	0.008	0.38	49

Questions can be grouped again with I5 relating to teaching science as a military operation, questions P4 and P5 focused on preparing future officers, P8 and P14 relating to science teaching practices and questions B5 and B10 connected to personal identity.

Item I5 was the only item with variance associated with teaching science as a military operation between these two military subgroups. One explanation for this singular item variance might be that formal teaching training programs were relatively new programs at some of the service academies (see section 2.1.3). Perhaps more scientifically experienced military instructors report lower influence of these programs simply because they did not exist on their first teaching assignment. The lack of additional variance in teaching science as a military operation suggests that this is one belief that is more strongly held on to. This general finding was identified in most military

subgroups as will be examined below. In this aspect data suggests that military instructors do not drift towards the more non-military model.

But in examining measures (items P4, P5) on the practice of preparing future officers (section 4.1), a variance can be identified between these two military subgroups. Responses on questions P4 and P5 indicate that less scientifically experienced military instructors report statistically significant greater practices of bringing non-science content into the classroom. Additionally, as military instructors gain a greater degree of scientific expertise, they report lower levels of adding non-scientific content to their lessons. This is the first piece of evidence suggesting the claim that the longer military instructors are in this academic setting, their pedagogic beliefs and practices can be located closer to the Chem Prof model. This also agrees with Avraamidou's findings that identities are dynamic, fluid, and under constant revision (Avraamidou, 2014, p. 164). Scientifically inexperienced military will have less time in academic settings compared to military instructors holding a PhD. As discussed in section 5.1.1, military careers are centrally managed, and when a military member is directed to obtain a PhD, they will typically miss out on a number of assignments of a more operational nature. Less experienced instructors could be termed "fresh from the fight", a military description used for those returning from combat deployments or rotating in from operational assignments (McLain, 2002). As such, these officers could be more likely to hold pedagogic beliefs and practices that they determine to be most beneficial to soon to commission officers about to join them as a military professional. Furthermore, military instructors who have obtained a PhD have perhaps become more committed to a profession of science and correspondingly report fewer military beliefs and practices when teaching sciences.

The author can add to this description from their own personal experience of obtaining a PhD while in the military. Although the author is obtaining a PhD in order to return for a second tour of teaching science at the US Air Force Academy, they are required to complete an assignment termed the Intervening Operations Tour between their two academically focused assignments. In the US Air Force this type of tour is euphemistically called a "re-blueing" assignment. This term is non-trivial as blue is the color of the USAF Class A uniform and section 5.1 presented aspects of how the uniform is connected to professional identity. The concept of re-blueing involves returning a military member

to an operationally focused military assignment to refresh their military mindset prior to sending them back to an academically focused setting (J. R. Johnson, Green, Soldwisch, Turner, & Wall, 1989). The understanding that this type of re-blueing assignment has been institutionalized as a regular part of an officer obtaining a PhD suggests that an identity drift towards a non-military approach has been historically identified in officers with academically focused assignments. The resulting effect is that that guidance for re-blueing tours has been provided to the centralized personnel office seemingly intended to reduce such drift.

Variances on pedagogic practices focused on science teaching (Items P8 and P14 and section 4.2.3) were also found between the sub group of military instructors based on their scientific training. Variations in these practices were not identified between military and civil servants (Table 29). Data shows that less experienced military science teachers report a higher practice of asking questions (item P8) and conducting physical demonstrations in class (item P14). Variance findings on these practices were also identified in other military subgroups involving teaching experience and if the military member was a service academy graduate themselves. An initial explanation for increased question asking will be offered now and supported with additional data as those other subgroups are presented.

Data from the combined findings support a theory that the more an instructor identified with the cadet experience, the more likely they were to support pedagogic practices intended to generate learning engagement. The service academy cadet or midshipmen experience is introduced in section 2.1.3. Between completing a baccalaureate degree, military training, required athletics programs and additional duties, the life of a cadet or midshipmen is extremely busy during the entire 4-year program at a US service academy (United States Naval Academy, 2015, p. 71). Even during the non-academic summer terms, a majority of a cadets' summer is schedule with training and cadets receive a total of 3 weeks summer leave (United States Air Force Academy, 2019, pp. 37–38). For a cadet there will always be more opportunities and homework than there will be time to complete them and cadets and midshipmen must practice effective time management strategies. This was the author's personal experience as a cadet themselves at two different service academies but it was also found in the data from science instructors' accounts. One Air Force instructor stated "[cadets] have so much more

going on, they're so busy. If they choose to prioritize another class over mine, I'm okay with that." In connecting this description of cadet life back to a possible explanation variance in pedagogic practices, the more an instructors could share an identity with this cadet experience, the more likely they were to utilize pedagogic practices aimed at capturing engagement such as asking lots of questions in class. This claim will be added to in future sections below.

The last two items (B5 and B10) reveal instructor beliefs about themselves and their students. Understandably, instructors with less academic training believe themselves less experienced in their field, item B10. A variance finding less easily explained involved less academically trained military instructors holding the belief that military instructors were better received by military students than civil servant instructors. Section 5.2.1 on hierarchy in the classroom could provide one theory. Less scientifically experienced military officers could be more sensitive to a military hierarchy in the classroom and less sensitive to an academic hierarchy. But as military officers gain greater scientific expertise in their fields, they also gain increased admiration for the scientific accomplishments of their civil servant counterparts in the classroom. This could translate into experienced military instructors holding a belief that cadets also share this understanding and respect for academic hierarchy. The exact explanation is unknown but this finding is an example of variance in military sub-groups and could additionally be added as another belief that will encounter drift in military instructors.

In summary this section has presented data and discussion on some of the variances in military instructors based on their scientific expertise. The next military subgroup to be examined is based on teaching experience.

Teaching Experience Subgroup

When examining for group variance of military instructors based on their teaching experience, several findings were discovered and are presented in Table 31. Novice teachers were considered instructors with less than four years of teaching experience while experienced instructors were considered as having 4 or more years of teaching experience (Hogan, Rabinowitz, & Craven III, 2003). .

Table 31: Significant variance in beliefs and practices between active-duty military instructors based on teaching experience

Survey Question	<4 yrs teaching exp Mean Rank	>4 yrs teaching exp Mean Rank	Mann-Whitney Test Statistic **U**	Standardized Test Statistic **Z**	Significance p (2-sided test)	effect size **r**	Sample size **N**
I5: My teaching has been influenced by continuing formal teacher training programs offered at my school.	28.53	20.11	191.000	-2.043	0.041	0.29	51
I7: My teaching has been influenced by continuing department training.	29.53	19.53	180.500	-2.418	0.016	0.34	52
P8: I try to make my lectures more engaging by asking a lot of questions during class.	29.36	21.53	219.000	-2.372	0.018	0.33	53
P14: I conduct physical demonstrations during class instruction.	29.31	20.42	198.000	-2.148	0.032	0.30	52
P2: I use novel learning technologies like student response systems ("clickers").	29.11	20.76	204.500	-2.019	0.044	0.28	52
P16: I utilize "flipped" classrooms with students completing readings before class.	29.16	20.68	203.000	-2.083	0.037	0.29	52
B10: I consider myself an experienced science instructor in my discipline.	20.70	30.83	156.000	-2.521	0.012	0.36	49

Variance findings on more than half of these items (I5, P8, P14, and B10) repeated findings presented in variance based on scientific expertise (Table 30). These repeat findings support the claim that the subgroups based on teaching experience and scientific expertise for military instructors were linked by elements of centralized career management. Discussion of repeat findings will be generally be omitted.

Two items (I5, I7) involved beliefs and practices associated with teaching science as a military operation. Variance on question I7 is similar to the repeat variance (item I5) on influence of school wide teacher training indicates that military instructors with less teaching experience report higher influence of continuing department teacher education.

The repeat finding on variance on items P8 and P14 provide additional support for the claim that as instructors better identified the cadet experience, the more they reported use of pedagogic practices involved with increasing student engagement. Variances on two additional pedagogic

practices items (P2 and P16) were found. The use of student response systems (also known as clickers,(MacArthur & Jones, 2008)) as well as flipped lessons (Long et al., 2017) are practices sometimes associated with active learning practices (Rau, Kennedy, Oxtoby, Bollom, & Moore, 2017). These two additional practices might be associated with the proposed theory of increased instructor identification with the cadet experience leading to increased engagement practices. Alternatively, instructors with less experience might have been more recently exposed to newer practices such as the use of clickers or flipped lessons during their teacher education programs (Korthagen, Loughran, & Russell, 2006). (Korthagen et al., 2006).

The previous two subgroups explored examined experience as it pertained to scientific expertise and teaching experience. The next subgroup examines military instructors who also had the experience of previously attending their institutions as students.

Service Academy Graduate Subgroup

One explored aspect of group variance was based on in military instructors were prior students of a military service academy. This subgroup was explored as officer instructors that were former students composed a larger set of officer population than typically in the military. 51% of the military science instructors reported being prior graduates yet the US service academies produce only 18% of total newly commissioned officers every year (see section 2.1.3). It is unknown if science departments actively select prior graduates or if prior graduates self-select for teaching positions. Regardless, findings revealed that there were only two items of variance between service academies graduates and non-military higher education graduates. Table 32 presents these findings.

Table 32: Significant Variance in Beliefs and Practices between Active-Duty Military graduates of a service academy and non-graduates

Survey Question	Grad (Active-Duty) Mean Rank	Non-Grad (Active-duty) Mean Rank	Mann-Whitney Test Statistic **U**	Standardized Test Statistic **Z**	Significance p (2-sided test)	effect size **r**	Sample size **N**
P8: I try to make my lectures more engaging by asking a lot of questions during class.	31.28	22.56	235.50	-2.664	0.008	0.37	53
B6: I identify well with my students.	30.22	22.48	237.00	-2.065	0.039	0.29	52

The first finding revealed that service academy graduates hold stronger beliefs in identifying with their students than non-graduates (item B6). This finding could be explained by the fact that these instructors were once former cadets and midshipmen themselves and possibly occupied some of the same physical seats as their current students (Pinto-Dror & Shoshana, 2022). These shared experiences between instructor and student could have led in increased instructor identification.

In examining pedagogic practices, former service academy graduate instructors reported a greater use of increasing class engagement through question asking (item P8). This is the final finding supporting the claim that instructor identification with students seemingly correlated with an increased pedagogic practice of question asking. This theory was further explored by grouping military instructors into four possible groups based on their scientific expertise (MS or PhD) and if they were a service academy graduate. These 4 sub-groups were statistically examined with a Kruskal Wallis test with the results presented in Table 33.

Table 33: Significant Variance in Practices between Active-Duty Military based on graduate status and scientific expertise

Survey Question	MS + Grad Mean Rank	PhD and Grad Mean Rank	MS + Non-Grad Mean Rank	PhD + Non-Grad Mean Rank	Kruskal-Wallis **H**	Degrees of Freedom	Significance **p** (2-sided test)	Sample size **N**
P8: I try to make my lectures more engaging by asking a lot of questions during class.	32.71	27.88	25.40	18.68	10.046	3	0.018	53

Service academy graduates with an MS degree reported the highest practice of question asking while non-service academy graduates holding a PhD reported the lowest use. It appears graduate status had a stronger effect than degree status as PhD service academy graduates reported a slightly higher practice than MS holding non-graduates.

Military Occupation Subgroup

The last military subgroup explored focused on military occupations of instructors in their regular military careers. This subgrouping was explored for several reasons. Section 2.1 describe several different sub-cultures within the military, often centered around different occupational missions, perhaps different occupations correlated with different pedagogic beliefs and practices. Additionally, these subgroups were explored based on the author's personal military experience and interaction with certain stereotypical career fields. As an example, military members who serve in special forces units fulfil some of the most physically demanding and dangerous combat roles (Maddi, 2007). Euphemistically these service members referred to as "hard core" or "snake eaters" with their intense training regimens and abilities to live off the land by literally eating snakes (Lin, 2008). Another stereotype might be of the fighter pilots who are generally regarded as prima-donnas with an extremely inflated views of themselves and their abilities (McGreevy & Otten, 2007). This is illustrated with the joke the author has heard of Question: What's the difference between God and a fighter pilot? Answer: God doesn't think he's a fighter pilot (Gawron, 2004). Finally, while these types of stereotypes and subcultures were suggested in the literature and experienced by the author, they were also captured in the instructor data. One such example included a department labelling an instructor as a "power tripping airborne officer" as presented in section 5.2.1.

In an attempt to explore this military subgroup, military instructors were requested to report their military occupation. These responses were coded into one of three profession categories: combat, STEM, or support (Moskos, 1981, p. 19), see section 3.2.3. The first category was titled Combat officers and included professions that would likely be present closest to the front lines of combat (Faulkner, 2008). Combat professions included pilots, navigators, submarine officers, surface warfare officers, infantry officers, and armor officers. These officers would likely have more "war stories", or

personal accounts of military experiences, to bring to the classroom. The second category was titled STEM officers and included chemists, physicist, biochemists, and engineers serving within the military. These military officers were often involved in the research and development of new military weapons and technology (Sellers, 2017). The nature of this professing suggests that these officers were the least likely to be utilized in combat roles. The last category was titled Support officers and it included all other military officer professions not in the previous two groups. Reported professions included military intelligence officers, medical officers, military police, and logistics officers (Woodson, 2019). In total, 19 officers were coded as combat, 18 as STEM officers, and 16 as support officers.

Analysis revealed no statistical variances in reported pedagogic beliefs, practices or influences between any of these military officer subgroups (Moskos, 1981, p. 19). The lack of finding significant variance between these groups was a surprise to the author. While possibly not a major finding in the context of the study, it did unseat a belief firmly held by the author about stereotypes within the US military. This finding of no variance served as a healthy reminder to all, but especially to those conducting insider research (Costley et al., 2010), to always let data speak for themselves.

In summary, the previous sections presented findings on variance between certain military subgroups based on scientific and teaching experience as well as variance on former graduates. The findings supported the model of variance and added additional discussion on the dynamic nature of beliefs. These provides some of the answers to the third research question investigating how beliefs and practices vary by groups. The following sections will examine subgroups of civil servants.

6.2.3 **Civil servant subgroup variance**

The active-duty military instructors and their various subgroups were presented in the previous section. This section examines subgroups of civil servant science instructors based similarly on teaching experience and military experience. This section will propose the finding that variance among civil servants and their subgroups occurred much less than among military subgroups.

Fewer subgroups existed among civil servants. The scientific expertise subgroup based on MS or PhD is not discussed as nearly all civil servants held a PhD (47/48). The military profession

subgroup was also skipped as a majority of civil servants never served in the active-duty military. Teaching experience was explored as well as the population of civil servants who did have military experience.

Teaching Experience as a subgroup

Variance in pedagogic belief and practice of civil servants based on teaching experience was explored. Military subgroups on teaching experience only included two cohorts (0-4 and 4+ years) while the civil servant subgroups one additional grouping of those with 12+ years teaching experience, see Table 34 (Hogan et al., 2003).

Table 34: Crosstabulation of teaching experience groups with Military and Civil Servant instructors

	Teaching experience at a service academy	
	Civil Servant Instructors	Military Instructors
Low (0-4 years)	11	39
Medium (4-12 years)	11	13
High (12+ years)	26	1
Total	48	53

Data showed that civil servants reported much more teaching experience than military instructors. While a majority of military instructors had less than 4 years, a majority of civil servants had over 12 years. The variances in pedagogic practice and belief between civil servant subgroups based on teaching experience are presented in Table 35.

Table 35: Significant Variance in Belief and Influences in Civil servants with various degrees of teaching experience.

Survey Question	Teaching Exp (0-4 yrs) Mean Rank	Teaching Exp (4-12 yrs) Mean Rank	Teaching Exp (12+ yrs) Mean Rank	Kruskal-Wallis **H**	Significance **p** (2-sided test)	Sample size **N**
I12: Other instructors' teaching materials have been invaluable to me as an instructor.	26.55	27.44	16.98	7.532	0.023	42
B2: It is desirable for department leadership to provide direction on how to teach science in the classroom.	31.09	27.91	20.27	6.067	0.048	48

Unlike the military that had several differences in pedagogic beliefs and practices based on teaching experience, data from civil servants indicates much less variance in practice and belief. Two items (I12 and B2) indicated overall significance with Kruskal-Wallis tests but follow on pairwise analysis revealed no significance between any pair. Mean Rank data from both items indicate that civil servant instructors with less than 12 years of teaching experience were influenced by other instructors teaching materials and department guidance. These findings could be explained by those civil servant instructors seeing no need for other instructor's materials considering their level of experience. Additionally, perhaps department pedagogic guidance is considered to be more of a nuisance in comparison to their own pedagogic beliefs and practices that have solidified over time (Chandler, 2013).

Civil Servants with prior military service

Since 8 of the 48 civil servants indicated that they had previously served in the military, variance was explored between those civil servants with a military background and those without. Table 36 shows that only one significant variance in pedagogic practice was identified between these two groups.

Table 36: Significant Variance in Practice in Civil Servants with military backgrounds

Survey Question	Civ w/ Mil Exp Mean Rank	Civ w/ NO Mil Exp Mean Rank	Mann-Whitney Test Statistic **U**	Standardized Test Statistic **Z**	Significance[1] **p**	effect size **r**	Sample size **N**
P9: I draw from military examples for illustrations of science in the real world.	31.25	20.56	74.00	-2.247	0.033	0.34	44

[1]Exact Significance [2*(1-tailed Significance)]

The only practice that varied between civil servants involved the use of use military illustrations when teaching science, a practice presented in section 4.2.1. This finding is could be explained with the idea that instructors draw material from their background (Harrison, 2001; Van Driel & Verloop, 1999). Civil servant instructors who have a military background will more readily be able to draw from it. Data from section 5.2.3 presented that just because civil servants did not have the first-hand experiences didn't mean they couldn't use military examples. In that section one civil servant instructor reported seeking out these types of military illustrations of scientific principles from

military instructors, in that instance degaussing a submarine as a context for presenting magnetic fields.

As only 1 variance was identified in the 8 civil servants with military backgrounds, it appears their pedagogic beliefs and practices are statistically similar to civil servant instructors without a military background. They expressed no beliefs or practices that appeared on the Classroom Commander end of the mode. These 8 instructors were further explored. In examining years of teaching experience along with military background, 6 of the 8 civil servants' instructors reported over 12 years of teaching experience. This indicated they had been separated from the military for some time. The lack of any additional between variation in this subgroup could be explained that with the decade or more of time as a civil servant they may they have drifted much closer to the Chem Prof side of the variance model (Avraamidou, 2014).

6.2.4 **Summary**

In summary, there are a number of variances between military and civil servant instructors (section 6.2.1). Military hold stronger military focused pedagogic beliefs and practices than civil servants. But that military group can be subdivided into subgroups that show there is variance based on scientific experience as well as teaching experience. Military graduates of a service academy also show variance in pedagogic belief and practices. Data showed that civilian instructors were a much more uniform group in their pedagogic beliefs and practices with very few variances. Less subgroups of civil servants were explored than of the military, perhaps the military background of the author influenced them to identify more subdivision of the military than of a non-military population. Data in section supported the model of variance as Classroom Commander at one end and a Chem Prof at the other. Data in this section also supported a dynamic element to pedagogic belief and practice in that those with more time in the academic setting tended to appear similar to a Chem Prof. The follow section examines the subgroups of Military branch and department that were not examined in this section.

6.3 Variance by military service and academic department

This section presents the variance in teacher practices and beliefs identified between the three different branches. In order to examine variance, it is useful to separate each branch into subgroups of military, see section 2.1 and civil servant instructors 6.3.2. Subgrouping was selected based on demographics of science teachers at the three service academies see Table 37.

Table 37: Branch Demographics by Military or Civil Servant

	Active-Duty Military	% Military	Civil Servant	Total
US Air Force Academy	28	74%	10	38
US military Academy	17	68%	8	25
US Naval Academy	8	21%	30	38
Total	53	100%	48	101

Table 37 shows that active-duty military composed 74% and 68% of respondents from the Air Force and Army, yet only 21% of Navy respondents were active-duty military. Section 6.2 presented that there were significant variances in practices between military instructors and civil servant instructors. To help identify variance connected to branches, both military instructors and civil servants will be examined individually

6.3.1 Variance in branch of service for active-duty military instructors

This section examines the variance in practice and belief of military officers at the three different military branches. Of the 45 measures examined, 11 measures had significant variance between the military officers. Table 38 presents the findings with at least a significance (p) <0.05 in a Kruskal-Wallis test. Follow on pairwise analysis identifies which branches were significantly different from each other.

Table 38: Significant Variance in Beliefs and Practices between Military Branches (Active-Duty Military), Deg of Freedom = 2

Survey Question	Army Mean Rank	Air Force Mean Rank	Navy Mean Rank	Kruskal-Wallis **H**	Significance **p** (2-sided test)	Sample size **N**	Navy-AF	Navy-Army	AF-Army
P4: I prepare non-science related content for presentation in class (such as "life lessons").	33.56	22.96	17.63	9.313	0.009	50		X	X
B4: It is important for all sections of a core science class in a department to keep the same teaching pace throughout the semester.	27.47	29.30	15.00	6.190	0.045	52	X		
I9: My teaching has been influenced by auditing other instructor's classes.	18.69	32.19	17.38	12.810	0.002	50	X		X
B5: Military instructors are better received by military students than civilian instructors.	31.50	20.31	32.81	8.688	0.013	51			X
B9: I see myself more as a scientist than as an instructor of science.	31.50	26.12	13.94	8.155	0.017	51		X	
P1: I utilize a graded online homework system.	20.85	27.31	35.75	6.169	0.046	52		X	
P2: I use novel learning technologies like student response systems ("clickers").	24.21	31.28	15.25	8.084	0.018	52	X		
P3: I use multimedia in my classes (slides, videos, etc.)	29.94	29.64	11.50	10.621	0.005	53	X	X	
P14: I conduct physical demonstrations during class instruction.	34.97	23.15	19.81	8.873	0.012	52		X	X
P15: I utilize "flipped" classrooms with students viewing recorded lectures before class.	34.59	22.69	22.19	11.841	0.003	52		X	X
P16: I utilize "flipped" classrooms with students completing readings before class.	27.91	29.33	13.94	7.345	0.025	52	X		

Findings can be grouped into four themes associated with previous findings, ideas on preparing officers (P4), ideas on teaching science as a military operation (B4, I9), beliefs on instructor identity (B5, B9), and variance on science content delivery practice (P1, P2, P3, P14, P15, P16).

When examine data on preparing officers for service, Army officers reported a significantly greater practice of preparing officers with practices such as "life lessons" than officers at either the Air Force or Navy. This finding agreed with interview data as Army instructors provided the strongest endorsement of delivering non-scientific content in the classroom in order to prepare their students for future military service. Data on teaching as a military operation indicated that the Air Force and Army held stronger beliefs in concepts such as standardization (item B4 and section 5.2.2) than the Navy. Air Force officers also reported a significantly greater influence of the practice of auditing other instructor's classes (section 5.1.2 on OJT).

When examining data on teacher identity, Army and Navy military instructors held stronger beliefs that military instructors were received better by military students (item B5) while the AF held more neutral beliefs about the difference. The Army and AF held stronger conceptions about their identity as a scientist over a science instructor.

When examining practices in the classroom (items **P1, P2, P3**, P14, P15, P16) There were trends in various traditional teaching practices. Military science instructors at the Navy reported significantly higher use of an online homework system (item P1) while Air Force and Army instructors were more likely to use clickers and slides during their classroom teaching (items P2 and P3). The Army reported the highest degree of physical demonstrations in the classroom, significant from both the Air Force and Navy (item P14). The Army also reported a higher practice of flipped classrooms (items P15 and P16) as compared to the Air Force and Navy.

The next section will examine differences between civil servants at the different branches.

6.3.2 Variance in branch of service for civil servant instructors

This section examines the variance in practice and belief of civil servants at the three different military branches. Of the 45 measures examined, 9 measures had significant variance between the civil servant instructors. Table 39 presents the significant ($p < 0.05$) findings in a Kruskal-Wallis test between the branches (cite). Follow-on pairwise analysis identifies which branches were significantly different from each other as a pair. Civil servants shared four service specific variances with their military counterparts (P2, P4, P15, P16).

Table 39: Significant Variance in Beliefs and Practices between Military Branches (Civil Servants)

Survey Question	Army Mean Rank	Air Force Mean Rank	Navy Mean Rank	Kruskal-Wallis **H**	DoF	Significance **p** (2-sided test)	Sample size **N**	Navy-AF	Navy-Army	AF-Army
P4: I prepare non-science related content for presentation in class (such as "life lessons").	32.50	28.94	17.39	14.73	2	0.001	44	X	X	
I4: My teaching has been influenced by school wide training provided on arrival.	22.63	30.75	18.31	6.85	2	0.033	42	X		
I5: My teaching has been influenced by continuing formal teacher training programs offered at my school.	10.94	31.94	21.54	12.29	2	0.002	42			X
I6: My teaching has been influenced by department training provided on arrival.	32.56	28.88	15.83	15.67	2	0.000	42	X	X	
I11: I receive a lot of direction from my leadership on how to teach my science classes.	24.88	30.81	17.60	8.72	2	0.013	42	X		
P2: I use novel learning technologies like student response systems ("clickers").	17.69	31.39	20.08	7.36	2	0.025	43	X		
P10: I create opportunities in class for students to teach each other.	29.38	30.28	17.87	9.76	2	0.008	44	X		
P15: I utilize "flipped" classrooms with students viewing recorded lectures before class.	31.38	22.44	19.89	9.21	2	0.010	44		X	
P16: I utilize "flipped" classrooms with students completing readings before class.	35.63	24.17	18.06	12.53	2	0.002	44		X	

Findings can be grouped into three themes, ideas on preparing officers (P4), ideas on teaching science as a military operation focused on hierarchy (I4, I5, I6, I11), and variance on science content delivery practice (P2, P10, P15, P16).

Similar to Navy military instructors, Navy civil servants report a significantly lower practice of preparing officers with non-science content compared to those at the Army or Air Force. Variance of military by branch showed that military officers had different variance on how teaching science as a military operation (see Table 38). Variance (items I4, I6, I11) of civil servant instructors reveals that Army and Air Force civil servants report a higher influence of teacher education programs (see Section 5.1.2) and the influence of hierarchy (section 5.2.1) on their teaching practices.

The practice of using technology such as clickers (item P2) was also found to be significantly higher among Air Force civil servants. As this is related to technology maybe the AF is more reliant on technology (**P2**, P10, **P15**, **P16**). Army and Air Force civil servants report a higher degree of creating opportunities for students to teach each other (P10). Similar to the military instructors Navy civil servants reported the lowest practice of flipped classrooms (items P15 and P16).

6.4 Other findings in variance: scientific discipline and gender

Two other groupings were discovered during answering the research questions on how do groups vary. These two groupings are based on scientific discipline (i.e. chemistry, physics) and gender. These findings contribute to answering to the research questions but have very few connections to previous findings focusing on the military setting of things.

Scientific discipline

Attempts were made to explore variance by scientific discipline (chemistry, physics, biology) but this subgrouping of instructors was more difficult to examine. For example, physics instructors were also members of a physics department and departments have been previous presented. Furthermore, while each service academy had both a physics and chemistry department, each service academy took a different approach to biology or the life sciences. As presented in section 2.1.3, the Air Force had a separate biology department, the Army had a life science sub-department within their chemistry department and the Navy did not offer life sciences as a scientific discipline. To address this inconsistency, the AF biology department was not included in variance analysis. Three chemistry departments were compared against three physics departments. Lastly, 39% of chemistry instructors

were active-duty military while 60% of physics instructors were active-duty, these different ratios of military and civil servant could have added confusion to the scientific discipline (see Table 40).

Table 40: Scientific discipline cross-tabulated with Military or Civilian instructor status

	Active-Duty Military	Civil Servant	Total
Chemistry	15	23	38
Physics	30	20	50
Total	45	43	88

Variance on in teaching practice and belief based on scientific discipline base are displayed in Table 41. Similar to previous tables, questions can be grouped into ideas on identity beliefs in experience (B10), teaching practices (P1, P7, P15, P16), and influence questions suggesting military operations (I6, I7, I12, I13, I14).

Table 41: Significant Variance in Beliefs and Practices between Physics and Chemistry Instructors

Survey Question	Chemistry Mean Rank	Physics Mean Rank	Mann-Whitney Test Statistic **U**	Standardized Test Statistic **Z**	Significance **p** (2-sided test)	effect size **r**	Sample size **N**
B10: I consider myself an experienced science instructor in my discipline.	**50.88**	38.91	670.500	-2.328	0.020	0.25	87
P1: I utilize a graded online homework system.	36.64	**47.67**	653.000	-2.127	0.033	0.23	85
P7: I demonstrate solving example problems.	**50.96**	36.46	561.500	-2.884	0.004	0.31	84
P15: I utilize "flipped" classrooms with students viewing recorded lectures before class.	35.89	**48.22**	626.000	-2.915	0.004	0.32	85
P16: I utilize "flipped" classrooms with students completing readings before class.	29.04	**53.26**	379.500	-4.630	0.000	0.50	85
I6: My teaching has been influenced by department training provided on arrival.	34.69	**45.80**	584.000	-2.176	0.030	0.24	81
I7: My teaching has been influenced by continuing department training.	33.27	**47.63**	534.500	-2.799	0.005	0.31	82
I12: Other instructors' teaching materials have been invaluable to me as an instructor.	31.16	**49.20**	460.500	-3.632	0.000	0.40	82
I13: My leadership provides valuable direction in regards to teaching practices.	34.43	**46.77**	575.000	-2.460	0.014	0.27	82
I14: I regularly seek the advice of other instructors.	35.33	**47.11**	606.000	-2.332	0.020	0.26	83

Generally, chemistry instructors believed they were more experienced in their scientific discipline (B10) and reported a higher practice of demonstrating practice problem solving (P7). Generally, physics instructors reported higher accounts of online homework systems and flipped classrooms (P1, P15, P16). Additionally, physics instructors reported higher accounts of influences suggesting teaching science as a military operation (I6, I7, I12, I13, I14). The data suggests that physics instructors hold beliefs that appear more "militaryish" but in light Table 40, the military-civil servant variances could have been the source of the physics/chemistry differences(see section 6.2), and individual departments variance (see section 6.4). This minor finding was a variance that contributed towards answering the research question on group variance. A second minor finding of variance based on instructor gender was also identified.

Gender variance

One variance between groups was identify based on gender. Table 42 shows that female instructors reported a statistically significant higher accounts of demonstrating problem solving (P7) and dedicating time for students to solve problems in class (P12).

Table 42: Significant Variance in Beliefs and Practices based on Instructor Gender

Survey Question	Male Instructors Mean Rank	Female Instructors Mean Rank	Mann-Whitney Test Statistic **U**	Standardized Test Statistic **Z**	Significance **p** (2-sided test)	effect size **r**	Sample size **N**
P7: I demonstrate solving example problems.	44.2	58.1	634.00	-2.35	0.019	0.24	95
P12: I dedicate time for students to work problems during class.	42.5	64.6	491.00	-3.61	0.000	0.37	96

Similar to the findings on military profession having no influence on teaching practices or beliefs, these finding on gender were somewhat unexpected to the author. The author held no conceptions of variance in teaching practice between male and female science instructors. These findings do not contribute to a military theme present in this study but do agree with other findings in educational literature (Nelson Laird, Garver, & Niskodé-Dossett, 2011; Starbuck, 2003), and provides additional contribution towards answering the research questions.

6.5 **Chapter summary**

This chapter explored variance in instructors' beliefs and practices primarily based on military versus civil servant as well as by which military service the instructor worked for. The overall explanation for how variance presented itself was based on how close each instructor's identity, see section, was "to the fight". (Avraamidou, 2014). For example, a young military instructor fresh from a military assignment would the more likely to report beliefs and practices very in line with the way military does things as expressed in chapters 4 and 5. At the other end of spectrum were some civil servant instructors with decades of experience who might be more representative of a traditional way of higher education as found in non-military schools. In addition to simply examine individuals, certain groups such as departments and services also held stronger beliefs in certain concepts of "militaryness"

7 CONCLUSION

This chapter provides the concluding thoughts on a study that identified a gap in knowledge about what science teachers in the US military believe about teaching science and their practices in doing so. In response to the gap, research questions were generated and an exploratory study was developed and executed. Section 7.1 of this chapter highlights some of the key findings as answers to the research questions. Section 7.2 presents the significance of those findings and how gaps in knowledge about military science teachers' beliefs and practices has been addressed. Section 7.4 finishes with how these findings can be applied and along with some ideas for future research studies.

7.1 Key findings as answers to the research questions

This study set out to answer research questions about what teachers believe about teaching, what teaching practices they claim to utilize, how these are influenced by a military setting and how they are different in different military settings (see section 2.3). This section concisely states the key findings for each research question although detailed findings were presented in chapters 4 through 6.

Research Question 1: What are the reported pedagogic beliefs and pedagogic practices of science instructors at the US service academies?

In addressing this question, it was discovered that teachers at the US military service academies held a spectrum of beliefs about teaching described as both traditional and progressive in the literature (see section 2.2). Some beliefs were to be expected from the literature such as teachers generally holding beliefs about learning being best accomplished when students took an active part in the classroom. This belief appeared to serve an explanation for teaching practice of using board work, a type of recitation where students move to the white boards to practice problems during class (see section 4.2). While a variety of beliefs is commonly found in literature (Bryan, 2012; Fives & Buehl, 2012; Pajares, 1992), one possibly unique set of beliefs found was instructors' beliefs on the aims of science education, see section 4.1. Instructors' beliefs about science education appeared nested within a larger belief system (Rokeach, 1968) about instructors having a mission of preparing officers for military service. This mission mindset belief framework provided an explanation for other beliefs and practices. An example of one such connected practice was several science teachers reporting that in

addition to presenting scientific content in the classroom, they also practiced delivering non-scientific content, such as life lessons, during classroom time (see sections 4.2 and 6.3).

Research Question 2: What are the reported influences on science instructors' pedagogic beliefs and practices?

Beliefs literature in section 2.2.1 suggested that beliefs could be influenced by numerous factors such as past experiences an current settings (Fang, 1996; Fives & Buehl, 2012; Kagan, 1992; Mansour, 2009; Pajares, 1992; Thompson, 1992) and findings of this study generally supported this claim (see section 5.1). But a key finding was rather than referencing ways they had been taught in academia, many instructors had recently arrived fresh from active-duty military assignments and referenced those experiences. Many of these instructors reported teaching beliefs and practices that appeared to be influenced by how they learned to fly an airplane or how they learned to shoot a rifle, as opposed to how they learned science in undergraduate education (see section 5.1). Certain teachers held beliefs about the high value of hands-on practice and training based on the utility of such practices in their military professions. This appeared to explain another key finding that several instructors reflected on the differences between the practice of training versus education and how one was not a substitute for the other (see section 4.2).

In addition to past experiences, teachers' beliefs were also influenced by the physical and cultural active-duty military setting. A key finding on this study was the discovery of how beliefs and practices involving the military concepts of hierarchy, standardization, and camaraderie were found as a way of teaching science for many instructors (see section 5.2). Hierarchy was found as department leaders had strong influences on shaping department members' beliefs about teaching and their practices. The standardization in teaching science was documented in the practice of instructors teaching the same course following nearly identical scientific content at the same pace utilizing standardized assessment materials. The practice of standardization was accompanied with a practice of camaraderie that existed between science teachers. Teachers were documented actively and freely sharing all of their academic teaching materials and novice and experienced instructors met regularly for purposes of sharing teaching advice.

Research Question 3: How do these beliefs and practices vary between groups in the military?

Several different groups were explored within the military setting and several groups held teaching beliefs and practices that were different to the other (see chapter 6). The largest and most significant group differences existed between those teachers with and without active-duty military service (see section 6.2). These findings were expected as they aligned with previous findings on how instructors were influence by their different prior experiences and backgrounds. Civil servant instructors generally held beliefs about teaching and practices that were less focused on producing officers and more focused on developing the scientific acumen of their students. Civil servants also appeared less influenced by issues such as hierarchy, standardization and camaraderie compared to their military counterparts. It was also discovered that the longer the active-duty military instructors remained in the academic setting the more their beliefs about teaching and practices began to align with those of their civil service counterparts, a finding that agreed with the literature on belief formation (see section 6.2 and 2.2).

Another key finding on the difference between groups was uncovered by examining groups by military service branch (army versus air force versus navy) (see section 6.3). Army instructors spoke of beliefs and practices of value in army military operation such of adhering to the commander's intent and to the value of training as it pertained to teaching science. Air Force instructors mentioned the pursuit of standardization in science teaching, a practice that was reported as useful when following instruction manuals and repairing aircraft. Navy instructors expressed the strongest beliefs in maintaining academic freedom as possibly connected to their freedom at sea during military operations. These differences in teaching beliefs and practices seemed to correlate differences between the cultures within the US military (see section 2.1) The answers to all the research questions does not indicate that there were not limitations to the study.

7.2 **Limitations of the study**

This study was limited in several ways. Even though the methods for investigating instructors' beliefs were carefully developed, beliefs still cannot be directly observed (Pajares, 1992). This limits the strength of any claim that a certain belief existed as the belief had to be reported or inferred. This study was also limited in that it only collected reported instructor teaching practices as

opposed to observing them directly. Due to the second-hand nature of both the beliefs and practices data, the study is limited in its ability to make definitive contributions to the consistency or inconsistency arguments. This study was also limited in that was only descriptive in nature. The study did not seek to change either the beliefs or the practices of teachers and no experiment was conducted. This study was also limited by the nature of the researcher. While the military background of the researcher certainly provides a unique research lens, every perspective will contain its own set of biases and deficiencies. Finally, this study was limited in its scope and generalizability (Bryman, 2016, p. 163; Maxwell, 1992). The study only examined instructors in a military context. Furthermore, it only examined military instructors from the US military and only those at the undergraduate level. Despite the limitations of the study, the uniqueness of the findings drive the significance of this study.

7.3 Significance of the study and the filling of a gap in knowledge

This study was significant because it examined rarely studied military instructors practicing science education in a rarely examined military setting. The findings for these research questions are significant as a result of the military setting and they close an important gap in knowledge about higher education in the military.

Section 2.1 presented how almost no literature exists that documents science teachers working within the military. Although a small number of studies have been conducted on military teachers in general at US military service academies. This study closes the gap in knowledge in that it focuses solely on the beliefs and practices of teachers of science. Furthermore, the few prior studies only examined military instructors in one branch of service, this study examined and compared science teachers from all three major US military service branches. Not only did this study close a general gap in knowledge about military science teachers, it demonstrated how different military culture led to different beliefs and practices in the teaching of science.

While not an objective of a research question, this study also makes a contribution to knowledge in that it was conducted by an atypical education researcher (see section 3.1). Most of the literature on teachers' beliefs developed was produced by researchers that came from backgrounds

within traditional academia (see section 2.2). This study was produced by a researcher not traditionally in academia. To the author's knowledge, there are no other researchers with a military background that conduct research on teachers' beliefs. The atypical background and experiences of the researcher created an atypical analytical lens through which this study was designed and executed as well as how the data was interpreted. By examining the author's interpretations, explanations and choices contained in the study, others can gain understanding of how a researcher with a military background might find different interpretation of topics within science education. This significance of this study leads to applications of these findings and possible areas of future study.

7.4 Applications of the findings and suggested areas of future study

Several applications of the findings can be suggested and areas for future study proposed. First, findings from this study could be applied to future researchers looking to gain access to and study military members or other aspects of the US military setting. This study detailed working through access issues that could be applied by researchers desiring gain access to participants within the military. It presented a description of the military useful to non-military researchers looking to understand aspects of rank and there might be differences between active-duty military and the civil servants they work with. Furthermore, this research could help future researchers avoid ethical missteps in studies involving military members conditioned to saying yes and following orders. Section 3.2 presented how the general compliance found in military members could hinder truly genuine voluntary consent. Correspondingly, section 5.2 presented how many military members appeared more comfortable with following a teaching style if it was a directed practice from leadership. Another application might be assisting researchers in finding a sample of instructors possibly more predisposed to following an experimental teaching practice protocol. Finally, the findings of this study could be relevant to the department leaders and science instructors at the US military service academies. Accounts of what other military instructors believe and practices could greatly assist military science teacher in being reflective about their practice and their professional development. Military instructors might be surprised at the diversity and similarities between other

instructors who generally share a mission of teaching science to aid in the development of future officers.

Along with applications, there are several future areas of study that could build on this research effort. This study was exploratory in nature and sought to balance breadth and depth and utilized both qualitative and quantitative methods. Future researchers could expand the sample size by including not just the science instructors, but all of the instructors at the US military service academies. Further development might include examining instructors at not just the undergraduate level only, but also the post graduate military school settings. Alternatively, future research could build depth in the conceptions about teaching science in the military by conducting a case study of a small sample of military science teachers (Swaim, 2013). While this study was novel in that it examined military instructors, it was limited in scope and it did not examine science instructors outside of the military in traditional civilian schools concurrently. A future line of research might include a comparison of the responses of teachers in a military setting with those of civilian instructors in a non-military setting. A possible study could measure traditional civilian science instructors' responses to some of the more military focused interview and survey questions. If there are science instructors with prior military experiences working in civilian schools, do these instructors draw from their military experiences when teaching science? Future studies might examine instructors at non-US military schools in different countries, this study was limited to the US military setting and gaps in knowledge exist in other militaries. Finally, due to scope limitations this study only measured reported practices and not observed practices. A future study might collect beliefs data along and compare them with actual observed practices in the classroom. Perhaps the military setting and military science instructors might add new evidence to the consistency or inconsistency arguments focused on explaining how or if beliefs translate into practice.

In conclusion, this study made substantial contributions to knowledge in that it narrowed a gap in knowledge about rarely studied military teachers in a rarely studied military setting by a rarely encounter military education researcher. It also forged an initial pathway between two rarely interconnected topics, science education and the US military.

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APPENDICES

Appendix A: Interview schedules

Interview Schedule for Science Instructors

Demographics (Rapport Building)

These questions are to gain a background on the experience of the instructor while at the same time building rapport between the interviewer and interviewee. Similar questions have been used in previous studies (Coffey & Gibbs, 2002; Luft & Roehrig, 2007; Norton et al., 2005).

- (Briefly) What has your occupation in the US military been prior to this teaching assignment?
- What led you to becoming a teacher at a service academy?
- How many years of teaching experience in higher education do you have?
- What subjects/classes have you taught?
- Have you been in a teaching or training position prior to this assignment?
- Did you participate in a teacher training program at your institution? (how many hours?)
- How beneficial to you was that new teacher training program?
- Have you participated in any other formal or informal teacher training?

Individual Beliefs on teaching

Questions 9-11 are taken from the Ho et al. (Ho et al., 2001)
Questions 12-18 are taken from the "Teacher Beliefs Interview" developed by Luft and Roehrig (2007).

- What is teaching?
- What is learning?
- What are the desirable learning outcomes for this course?
- How do you maximize student learning in your classroom?
- How do you describe your role as a teacher?
- How do you know when your students understand?
- In the school setting, how do you decide what to teach and what not to teach?
- How do you decide when to move on to a new topic in your classroom?
- How do your students learn science best?
- How do you know when learning is occurring in your classroom?

Context Questions

These questions seek to describe the context the instructors operate in and the influences on their beliefs and approaches to teaching. Context is important (Becher & Trowler, 2001; Kember, 1997; Norton et al., 2005) and a major part of this study is to describe the military setting.

- How has the context of a US service academy shaped the way you teach? (physical/social)
- How much freedom are you given in the way you are allowed to teach?
- Would you teach differently if you were allowed to?
- Do you ever teach about topics not related to your specific course?
- Do you actively manage power relations in your classroom?
- Have career progression motivations shaped the way you teach?
- How important do you think your development as an instructor is to your leadership?
- Do you feel your leadership actively tries to shape the way you teach? If yes, how?

Are there any additional comments you would like to make about being a science teacher?

Interview Schedule for Department Heads

Demographics (Rapport Building)

Much of the background of deans and department heads is available in the form of biographies. These biographies will be reviewed in advance and this rapport building phase will allow these leaders to express their story in their own words. These questions are to gain a background on the experience of the instructor while at the same time building rapport between the interviewer and interviewee. Similar questions have been used in previous studies (Coffey & Gibbs, 2002; Luft & Roehrig, 2007; Norton et al., 2005).

Answers to these questions might be available from bios, clarify if not available.

- (Briefly) What have your occupations in the US military been prior to this teaching assignment?
- What led you to becoming a leader of teachers at a US service academy?
- How many years of experience do you have leading teachers in higher education?
- Have you been in a teaching/training position prior to this assignment?
- How have you been involved in your department (or institution's) teacher training program?
- Do you still actively teach in the classroom?
- How many years of teaching experience in higher education do you have?
- What subjects/classes do you teach?
- Have you ever personally received any teacher training either formal or informal?

Individual Beliefs on teaching

Questions 10-12 are taken from the Ho et al. (Ho et al., 2001)

Questions 13-19 are taken from the "Teacher Beliefs Interview" developed by Luft and Roehrig (2007).

- What is teaching?
- What is learning?
- What are the desirable learning outcomes for this course?
- How do you maximize student learning in your classroom?
- How do you describe your role as a teacher?
- How do you know when your students understand?
- In the school setting, how do you decide what to teach and what not to teach?
- How do you decide when to move on to a new topic in your classroom?
- How do your students learn science best?
- How do you know when learning is occurring in your classroom?

Context Questions

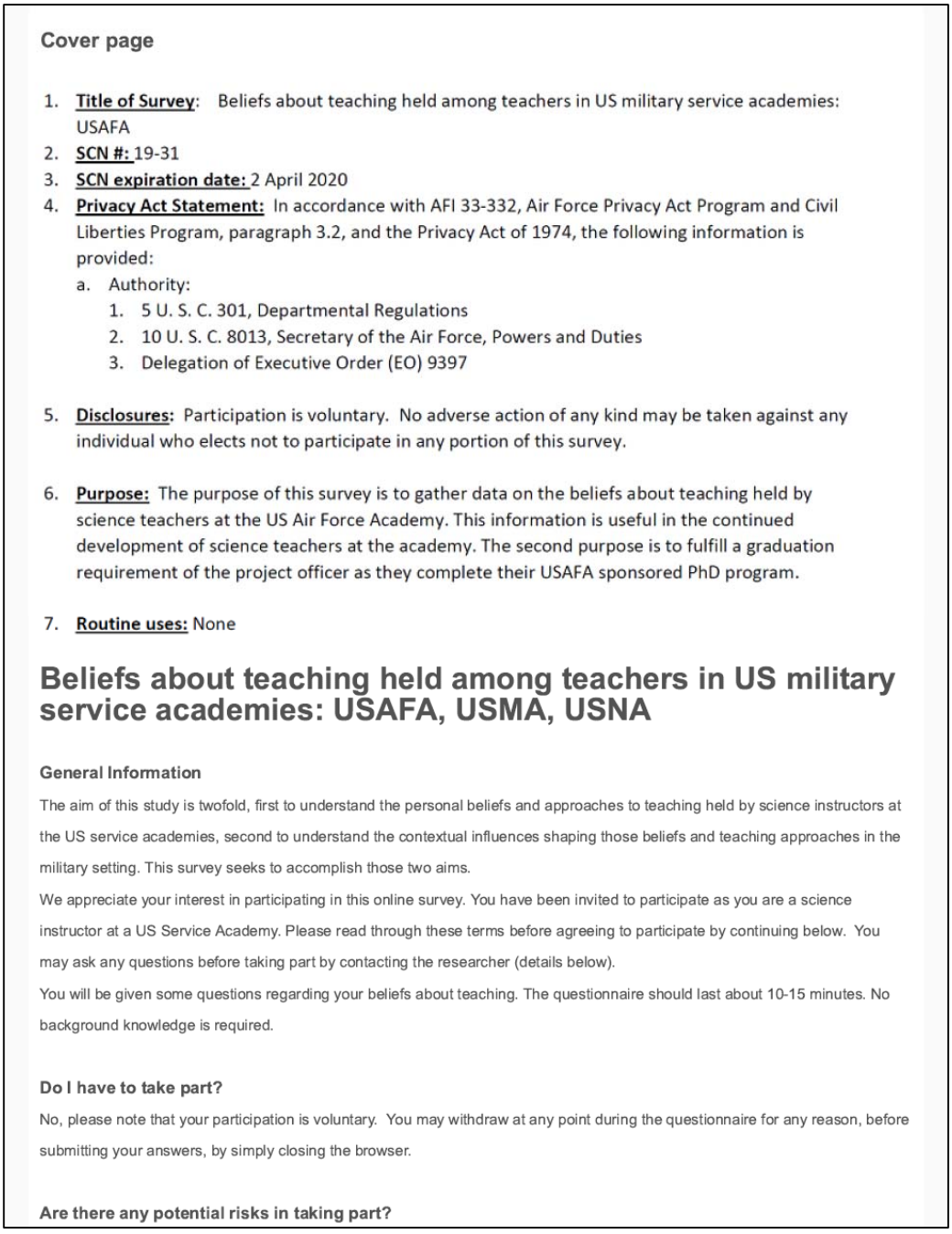
These questions seek to describe the context the instructors operate in and the influences on their beliefs and approaches to teaching. Context is important (Becher & Trowler, 2001; Kember, 1997; Norton et al., 2005) and a major part of this study is to describe the military setting.

- What is your general philosophy on how you develop the teaching abilities of your instructors?
- How has the military context influenced your efforts towards developing your instructors?
- How much freedom do you allow your instructors in the way they teach?
- Do you actively manage power relations between yourself and your instructors?
- How important is your instructor's teaching development in light of their career development?
- If you were studying science instructors across the military service academies, what would you want to know? (added during fieldwork)

Are there any additional comments you would like to make about being a leader of science teachers?

Appendix B: Survey

The survey was administered online and following images show how a survey would be viewed by a participant. Some Likert response options as discussed in section 3.3.2 have been clipped to fit on the page. Participants would see the full range of responses such as “strongly agree”, “somewhat agree”, “neither agree nor disagree”, “somewhat disagree” and “strongly disagree” or “every lesson”, “most lessons”, “about half of the lessons”, “some lessons”, and “never”.



Cover page

1. **Title of Survey**: Beliefs about teaching held among teachers in US military service academies: USAFA
2. **SCN #:** 19-31
3. **SCN expiration date:** 2 April 2020
4. **Privacy Act Statement:** In accordance with AFI 33-332, Air Force Privacy Act Program and Civil Liberties Program, paragraph 3.2, and the Privacy Act of 1974, the following information is provided:
   a. Authority:
      1. 5 U. S. C. 301, Departmental Regulations
      2. 10 U. S. C. 8013, Secretary of the Air Force, Powers and Duties
      3. Delegation of Executive Order (EO) 9397
5. **Disclosures:** Participation is voluntary. No adverse action of any kind may be taken against any individual who elects not to participate in any portion of this survey.
6. **Purpose:** The purpose of this survey is to gather data on the beliefs about teaching held by science teachers at the US Air Force Academy. This information is useful in the continued development of science teachers at the academy. The second purpose is to fulfill a graduation requirement of the project officer as they complete their USAFA sponsored PhD program.
7. **Routine uses:** None

Beliefs about teaching held among teachers in US military service academies: USAFA, USMA, USNA

General Information

The aim of this study is twofold, first to understand the personal beliefs and approaches to teaching held by science instructors at the US service academies, second to understand the contextual influences shaping those beliefs and teaching approaches in the military setting. This survey seeks to accomplish those two aims.

We appreciate your interest in participating in this online survey. You have been invited to participate as you are a science instructor at a US Service Academy. Please read through these terms before agreeing to participate by continuing below. You may ask any questions before taking part by contacting the researcher (details below).

You will be given some questions regarding your beliefs about teaching. The questionnaire should last about 10-15 minutes. No background knowledge is required.

Do I have to take part?

No, please note that your participation is voluntary. You may withdraw at any point during the questionnaire for any reason, before submitting your answers, by simply closing the browser.

Are there any potential risks in taking part?

In order to reduce any potential risks, all research data will be anonymized to the greatest extent possible. It might be possible that your position is so unique that answers you provide during the interview could reveal your identity by the nature of your position. As such, please understand that full anonymity might not be possible for those in those very unique positions.

How will your data be used?

Your response is part of a survey to understand beliefs of science teachers in a military context. It is the ultimate goal that the analysis of this data will lead to better teaching at the US service academies and a better understanding of teaching in general. Demographic data will be gathered but the questionnaire answers are completely anonymous.
Your data will be stored in a password-protected file and may be used in academic publications. If you prefer not to answer a particular question please simply skip it. Research data will be stored for a minimum of three years after publication or public release.

Who will have access to your data?

The University of Oxford is the data controller for the purposes of the Data Protection Act 1998. We would like your permission to use your anonymized data in future studies, and to share data with other researchers (e.g. in online databases). Any information that could identify you will be removed or changed before files are shared with other researchers or results are made public. Responsible members of the University of Oxford, funders may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines, or as otherwise required by law. Furthermore, the US Department of Defense may similarly access study records to ensure subjects' safety and regulatory compliance.
This questionnaire is for a DPhil project. The principal researcher is Major Erik Kappe, who is attached to the Department of Education at the University of Oxford. This project is being completed under the supervision of Dr Ann Childs. This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee [ED-CIA-19-060].

What if there is a problem?

If you have a concern about any aspect of this project, please speak to the researcher Major Erik Kappe (erik.kappe@education.ox.ac.uk or +44 7562 203726) or their supervisor Dr. Ann Childs (ann.childs@education.ox.ac.uk or +44 1865 274006), who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the Chair, Social Sciences & Humanities Inter-Divisional Research Ethics Committee; Email: ethics@socsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD. The Chair will seek to resolve the matter in a reasonably expeditious manner. Please note that you may only participate in this survey if you are 18 years of age or over.

By continuing I certify that I am 18 years of age or over, that I have read the information above, and agree to participate

Demographics Block

Section 1 of 4: Background information

Please answer the following background questions.

Which US service academy do you instruct at?

- ○ US Air Force Academy
- ○ US Military Academy
- ○ US Naval Academy

Which science department do you instruct for? (USAFA)

- ○ Biology
- ○ Chemistry
- ○ Physics

Which science department do you instruct for? (USMA)

- ○ Chemistry and Life Science
- ○ Physics & Nuclear Engineering

Which science department do you instruct for? (USNA)

- ○ Chemistry
- ○ Physics

What is your highest degree held?

- ○ Masters degree
- ○ Doctoral degree

What is your age?

- ○ Under 25
- ○ 26 - 30
- ○ 31 - 35
- ○ 36 - 40
- ○ 41 - 45
- ○ 46 - 50

- ○ 51 - 55
- ○ 56 - 60
- ○ 61 or older

How many years have you been teaching at a US service academy?

- ○ Less than 1
- ○ 1 to <2
- ○ 2 to <4
- ○ 4 to <8
- ○ 8 to <12
- ○ 12 to <18
- ○ 18 to <25
- ○ 25 or more

How many total years have you been teaching in all higher education?

- ○ Less than 1
- ○ 1 to <2
- ○ 2 to <4
- ○ 4 to <8
- ○ 8 to <12
- ○ 12 to <18
- ○ 18 to <25
- ○ 25 or more

What is your gender?

- ○ Male
- ○ Female

What is your status?

- ○ Active Duty Military
- ○ Civilian
- ○ Contractor
- ○ Other

Do you have previous active duty military experience?

- ○ Yes
- ○ No

Are you a graduate of a US service academy?

- ○ Yes
- ○ No

Upon arrival at your institution did you participate in a new instructor training program?

- ○ Yes
- ○ No

Have you voluntarily completed any additional instructor training offered by your institution? (Such as the Dean's Teaching Certificate Program [USAFA] or the Master Teacher Program [USMA], etc).

- ○ Yes
- ○ No

How many sections of your department's **core** science class do you teach **per year** (on average)? Note: all "core" class references in this survey refer to core curriculum classes at your institution required to be completed by all students.

- ○ Less than 1
- ○ 1 to < 2
- ○ 2 to <4
- ○ 4 to <6
- ○ 6 or more

In April of 2019, interviews with science instructors about teaching were complete across the service academies. If you participated in one of these interviews AND you are willing to have your interview data correlated with your survey data please indicate below. All data will still remain anonymous.

- ○ Yes I previously participated in an interview for this study

○ No I did not participate in an interview, OR I am not willing to correlate my interview data with this survey response

Instructor Beliefs

Section 2 of 4: Beliefs about teaching

This survey is primarily interested in capturing your beliefs about teaching science in the setting of a **core** classroom. Please use this reference point when considering your responses below. All "core" class references in this survey refer to core curriculum classes required to be completed by all students at your institution. All references to teaching science refer to teaching your department's scientific discipline (biology, chemistry, physics, etc).

Complete the statement: The most important thing for students to gain from my class is…

Please indicate your agreement or disagreement with each statement. All references to "science" refer to your department's scientific discipline (biology, chemistry, physics, etc).

	Strongly agree	Som ag
A. Instructors should feel comfortable utilizing teaching materials developed by other instructors.	○	(
B: It is good for department leadership to provide direction on how to teach science in the classroom.	○	(
C: If an opportunity presents itself, it is acceptable to utilize class time to focus on character development which might require students to learn scientific content on their own time.	○	(
D: It is important for all sections of a core science class in a department to keep the same teaching pace throughout the semester.	○	(
E: Military instructors are better received by military students than civilian instructors.	○	(
F: I identify well with my students.	○	(
G: Instructors with good teaching materials should share them with fellow instructors.	○	(
H: I fit in well at my institution.	○	(
I: I see myself more as a scientist than as an instructor of science.	○	(
J: I consider myself an experienced science instructor in my discipline.	○	(

	Strongly agree	Som ag
K: Students in a department's core science class should receive a uniform learning experience regardless of what section they are placed in.	○	(
L: Science instructors need to focus on the academic content in the classroom and leave the other institutional aims to other organizations.	○	(
M: Good instructors at US service academies should actively provide character or life skills lessons in addition to science content.	○	(
N: Good science instructors meet with other instructors to share best practices.	○	(
O: I fit in well in my department.	○	(

Complete the statement: My personal purpose at my institution is to…

Intentions

Section 3 of 4: Instructor methods

This section is aimed at capturing your typical activities in the classroom. Please continue using the mindset of teaching a **core** classroom when considering your responses below.

Complete the statement:
Instructors at US service academies teach their scientific disciplines best by…

Please indicate how often you utilize different teaching techniques. Please only consider regular teaching days and not days dedicated to assessment or laboratory.

	Every lesson
A: I utilize a graded online homework system.	○

	Every lesson
B: I use novel learning technologies like student response systems ("clickers").	○
C: I use multimedia in my classes (slides, videos, etc.)	○
D: I **prepare** non-science related content for presentation in class (such as "life lessons").	○
E: I utilize opportunities to discuss character development if they present themselves in class.	○
F: I draw from **non-military** examples for illustrations of science in the real world.	○
G: I demonstrate solving example problems.	○
H: I try to make my lectures more engaging by asking a lot of questions during class.	○
I: I draw from **military** examples for illustrations of science in the real world.	○
J: I create opportunities in class for students to teach each other.	○
K: I use an extended lecture format to teach science.	○
L: I dedicate time for students to work problems during class.	○
M: I provide supplemental learning materials to my class (such as lecture note packets or question packets).	○
N: I conduct physical demonstrations during class instruction.	○
O: I utilize "flipped" classrooms with students viewing recorded lectures before class.	○
P: I utilize "flipped" classrooms with students completing readings before class.	○
Q: I utilize a teaching technique not mentioned above. (if so, please list)	○

How many office hours (AI/EI) per week do you provide, on average?

- ○ Less than 1 hour
- ○ 1 to <2 hours
- ○ 2 to <3 hours
- ○ 3 to <5 hours
- ○ 5 to <8 hours
- ○ 8 or more hours

Influences

Block 4 of 4: Influences on your instruction techniques

This section seeks to identify the effect certain contextual influences might have on your instructional techniques.

Please indicate your agreement or disagreement with each statement.

	Strongly agree	Somev agre
A: My teaching has been influenced by personal teaching experience.	○	○
B: My teaching has been influenced by purposeful experimentation in the classroom.	○	○
C: My teaching has been influenced by reading educational literature.	○	○
D: My teaching has been influenced by **school wide** training provided **on arrival**.	○	○
E: My teaching has been influenced by **continuing** formal teacher training programs offered at my school.	○	○
F: My teaching has been influenced by **department** training provided **on arrival**.	○	○
G: My teaching has been influenced by **continuing** department training.	○	○
H: My teaching has been influenced by informal discussion with other science instructors.	○	○
I: I teach very similar to how I was taught in school.	○	○
J: I receive a lot of direction from my leadership on how to teach my science classes.	○	○
K: Other instructors' teaching materials have been invaluable to me as a instructor.	○	○
L: My leadership provides valuable direction in regards to teaching practices.	○	○
M: I regularly seek the advice of other instructors.	○	○
N: My teaching has been significant influences by the following factor not mentioned above? (if so, please list)	○	○

Complete the statement:

The most significant resource that could be provided to me that would allow me to become a better instructor is…

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