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A Comparative Accreditation Alignment Analysis of Civil Engineering and Construction Management Bachelor Degrees with the Skill Requirements for USAF Civil Engineer Officers

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A COMPARATIVE ACCREDITATION ALIGNMENT ANALYSIS OF CIVIL ENGINEERING AND CONSTRUCTION MANAGEMENT BACHELOR DEGREES WITH THE SKILL REQUIREMENTS FOR USAF CIVIL ENGINEER OFFICERS

THESIS

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Abstract

The United States Air Force Civil Engineer (CE) officer career field involves a host of duties and opportunities for technical competence and leadership excellence as the Air Force mission grows and personnel numbers shrink. Most CE officers spend their careers as a technical manager, performing a mixture of duties that require a wide variety of skills. Because of this, the use of engineering design skills have decreased and the use of project and construction management have increased. While the career field accepts a variety of architecture and engineering degrees for new accessions, technical management degrees like Construction Management have been denied. This study uses a Delphi study to rate a list of skills most needed by CE Company Grade Officers, and compares those skills with the accreditation outcomes for Civil Engineering and Construction Management undergraduate degrees. After 2 rounds of surveys, a list of 40 skills was used to compare the relative emphasis of the degrees. Construction Management was shown to emphasize higher rated skills. Civil Engineering still showed a high relation to the skills, but emphasized engineering design skills that were consistently rated lower by the Delphi panel. The research shows that accredited Construction Management display a better fit for CE officers and should not only be considered acceptable, but encouraged for new accessions.

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Josh Chambers-Mills

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A COMPARATIVE ACCREDITATION ALIGNMENT ANALYSIS OF CIVIL ENGINEERING AND CONSTRUCTION MANAGEMENT BACHELOR DEGREES WITH THE SKILL REQUIREMENTS FOR USAF CIVIL ENGINEER OFFICERS

I. Introduction

Background

Construction is the basis for everything that Civil Engineers do. Every design, plan, and specification is meant for someone to pay for, build, and use it. The management of construction as a field has been around since the 1920's, but as the needs for information technology, building complexity, and specialization grow, the formation of specialty construction management degrees have also grown (Abbas, Din, & Farooqui, 2016; Abudayyeh, Russell, Johnston, & Rowings, 2000). This education of construction management professionals works to link the engineering profession with the reality of construction which requires different skills and education.

With a continued refining of Construction Management in civilian sectors, the United States Air Force (USAF) Civil Engineer (CE) community has been progressively reducing unit engineering capacity and technical duties since the late 1980's (Culver, 2007). This reduction in technical engineering was met with an increase in construction and management roles, while the education requirements have largely remained the same. With the exception of Rapid Engineer Deployable Heavy Operations Repair Squadron (REDHORSE) squadrons, Air Force CE units do not retain in-house engineering capacity, and many have moved entirely to contractors for technical documents creation. While this change allows the USAF to use government civilians and fewer CE officers, known as 32Es, to accomplish the same job, the mentality of "engineering first" remains.

Education Details

This mentality is shown in the undergraduate degree requirements of an Architectural or Engineering degree from eight fields, shown in Table 1 (Department of the Air Force, 2016). While Construction Engineering is allowed, degrees like Construction Management or Project Management are not because they are not ABET accredited. There are currently 46 accredited Construction Engineering programs in the country, and 76 accredited Construction Management programs (ABET, 2017c; Marshall et al., 2017). The Air Force remains focused only on engineering, with an apparent disregard for the shifting foci of the construction industry and mission.

Table 1: Academic Degrees allowed in the USAF Civil Engineer Officer Career Field

Architecture
Civil Engineering
Electrical Engineering
Environmental Engineering
Construction Engineering
Architectural Engineering
Industrial Engineering
Mechanical Engineering

The Air Force publishes a Career Field Education and Training Program (CFETP), aimed at shaping the career field to current and future needs (Department of the Air Force, 2016). A career field pyramid with general guidelines for officers as to the positions they should hold based on rank is shown in Figure 1. This figure, while not

comprehensive, shows what is expected of the officer corps within different timeframes of a career.

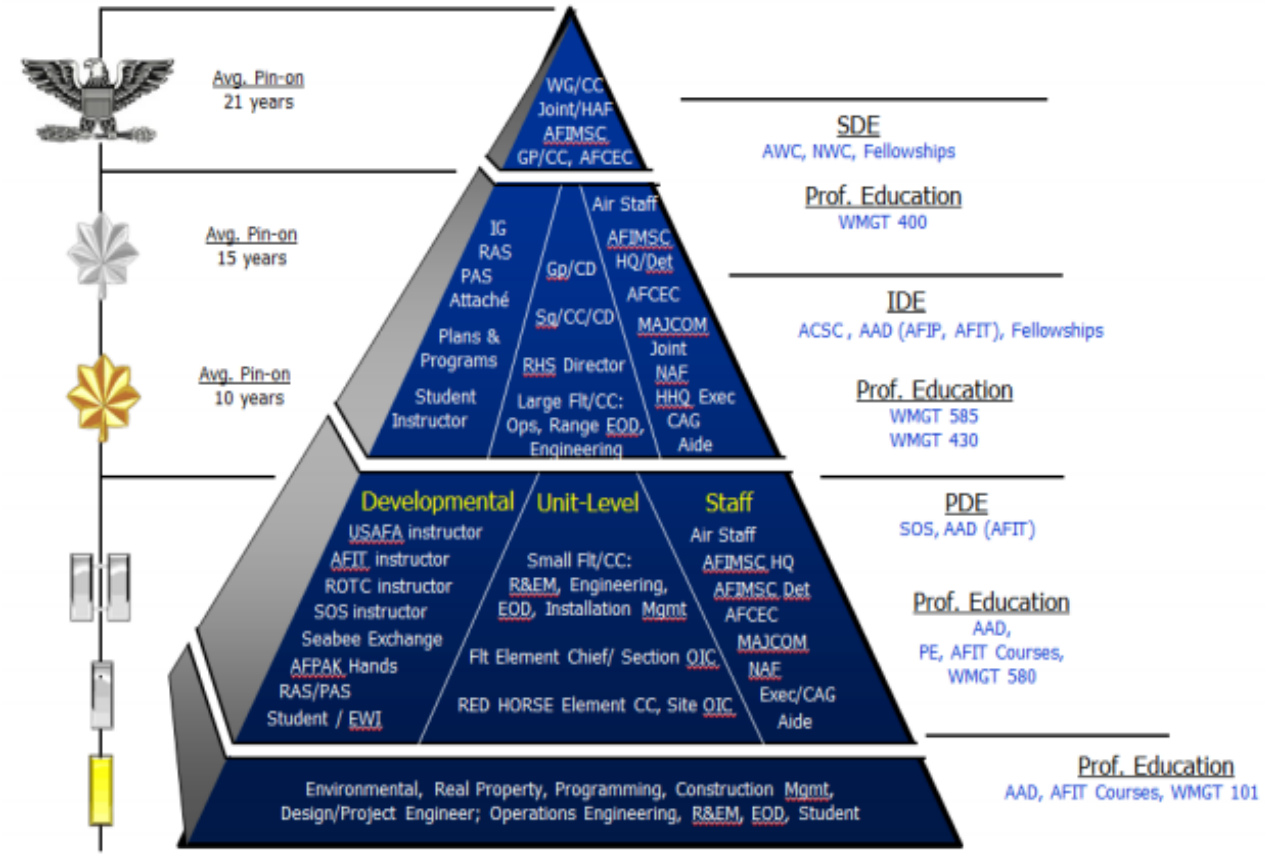


Figure 1: CE Career Development Pyramid, taken from USAF CFETP for CE Officers (Department of the Air Force, 2016)

The list of jobs in Figure 2 for 2nd Lieutenants, 1st Lieutenants, and Captains includes only one reference to design engineering, but includes four construction references and 14 management references. Based on its own documents, the Air Force Civil Engineer community is more interested in using officers for construction expertise, project engineering, and general management, while the education requirements emphasize technical degrees and skills. The role that young officers play in the USAF requires practical construction and management skills, which must be learned on the job

during a career, while the skills learned in the degree are often left unused.

Research Objectives

While the Air Force competes with other employers for new and retained talent, the constraint of engineering degree requirements for the Civil Engineer career field are limiting the pool of applicants and limiting the breadth of knowledge available within its officer corps. The purpose of this thesis is twofold: first, identify and measure skills that Civil Engineer officers need, gained either through education or on-the-job training; second, determine how well different degrees align with the skills in the CE career field. The skills needed to be a proficient 32E have evolved over time, and now encompass a broad spectrum of academic majors. This study will look at two undergraduate degrees, one that does not qualify for 32E's and one that does, to see if the skills obtained in each compare to what is needed for success.

Investigative Questions

1. What are the skills needed to be a successful Company Grade Officer (CGO) in the 32E career field?
2. What are the skills and abilities that graduates of Civil Engineering (CE) and Construction Management (CM) degrees have?
3. Are the degree program requirements of a CE or CM degree more aligned with the skills needed for the 32E career field?

Methods and Materials

The research will utilize a Delphi study to gather a list of skills from knowledgeable and experienced Subject Matter Experts (SMEs) within the CE career field. A Delphi study aims to provide a consensus within a group of experts. It involves

a series of questionnaires and feedback that allow the group to continually refine their responses. The group is given feedback with analysis of the group responses, which allows the individuals to analyze their responses compared to the group. The questions are then further refined by the survey administrator, which allows the group to converge on a consensus response (RAND Corp, 2017). The list developed by the Delphi study will then be compared to the accreditation Student Outcomes from Civil Engineering and Construction Management degrees.

This study will require minimal materials. A group of 8-12 people will be used for the Delphi study, taken from the CE career field. These Subject Matter Experts (SMEs) will be Air Force personnel and used based on professional experience and individual availability. The accreditation outcome review will require the degree requirements for CE and CM, which are publicly available.

Assumptions and Limitations

While students may take classes, graduates may not retain all of the skills or abilities. This study, however, assumes that graduates will retain the skills learned during degree completion, and looks to compare the broad foundational content of the outcomes for the degree requirements.

This study assumes that a definable list of skills for the career field is possible. Because the duties of a Civil Engineer Squadron are numerous and often variable, the duties that an officer performs within that squadron will be numerous and variable. This study will look at the skills that all CE officers need for their career to better align educational requirements with the functional requirements of the career.

The research will focus on Construction Management and Civil Engineering degrees. While the career field accepts eight different undergraduate majors, the study is focused on CE and CM. The research could be picked up to include different undergraduate degrees, like the seven other accepted degrees and Project Management or Program Management. This study could have implications for the hiring and training of 32E officers.

Summary

The remainder of this thesis will cover a review of applicable literature, a description of the methods used in gathering data, a discussion of the results, and finally, a conclusion to provide findings, recommendations, and future research opportunities.

II. Literature Review

Introduction

The education of USAF Civil Engineer officers includes professional training courses, on-the-job training (OJT), experience, and undergraduate degree requirements (Department of the Air Force, 2016). This thesis aims to close the gap between education and operations. By ensuring that the education requirements implemented by the Unites States Air Force (USAF) match the operational skills, the career field and the USAF can benefit from a more prepared and capable workforce.

Justification and Scope for Research

This research will study the skills and abilities that are needed according to Civil Engineer (CE) career field for new CE officers and compare those skills and abilities to the undergraduate education requirements imposed by the AF for the career field. To provide an in-depth analysis, this thesis will restrict the degree programs being analyzed. This will allow for future researchers to repeat a similar method to study other degree programs and comprehensively evaluate the current requirements.

Review of Literature

This thesis deals with three distinct areas: the broad goals and mechanisms of higher education, the roles and responsibilities of USAF CE officers, and the specific degree requirements of Civil Engineering and Construction Management (CM). Each of these subjects plays a part in how this thesis will answer the research questions from Chapter I.

Overview of Higher Education, Accreditation Requirements

To compare degree requirements to the skills that affect CE officers, the purpose of higher education needs to be understood. While no single defined goal or globally accepted role for higher education exists, there are a few theories and approaches. Andrés Fortino, a partner at Paradigm Research International and former Dean at two Universities, emphasized the greater purpose of higher education to create prepared minds, ensuring that individuals leave with an ability to contribute to their chosen profession (2012). To create these prepared minds, institutions and degree programs offer a wide variety of classes and tracks. The two main focuses of the education are character development and career development, often with tension rising from differing underlying goals and limited space in curriculum.

Bethany Sutton, Chief of Staff and Senior Advisor at the Association of American Colleges & Universities, also writes that higher education should be focused on teaching skills that apply to both job and personal performance (Sutton, 2016). She states that there are skills that should be taught that transfer from preparation for employment to problem-solving in the real world. She lists the following as skills that transfer: critical thinking, problem solving, working in diverse teams, ethical reasoning, and communicating. These skills, while aiding in job performance and career development, also drive social and community improvements.

While higher education should be focused on general education and creating prepared minds, many accreditation bodies work to control and focus the efforts of higher education in a specific field. Accreditation is a process that serves many purposes, first among them to verify that institutions or programs meet the applicable standards of the

accreditation body (Department of Education, 2003). The accreditation process requires each program to share information, usually both written and in-person, to ensure the program provides the minimum student outcomes for the profession (ABET, 2017b; Burt et al., 2013). There are 67 accreditation agencies across the country, including the Accreditation Board for Engineering and Technology (ABET) and the American Council for Construction Education (ACCE) (Department of Education, 2017). These private organizations provide specialized standards for programs with the goal of producing professionals in a field (Department of Education, 2003).

Because accreditation plays such an important role in what is taught, especially in technical degrees, it is important to know how accrediting bodies establish and maintain their standards. ACCE uses the programs in its portfolio and construction industry professionals to constantly update how institutions are educating students. The construction management industry is an equal partner with educators, according to ACCE, which uses an Industry Advisory Board to ensure that the practitioners have a say in the creation and implementation of standards (ACCE, 2018). The industry has seen the opportunity in this, going so far as to give additional resources to programs that experience over-enrollment to ensure that CM programs can continue to operate and produce well educated graduates (Christofferson, Wynn, & Newitt, 2006). ABET uses a similar feedback system, incorporating industry and academic professionals from their fields of expertise to evaluate programs (ABET, 2017a; ACCE, 2017). This feedback loop, incorporating academia, industry, and accreditation, ensures that professionally relevant skills are a part of education.

Accreditation bodies provide institutions and programs with a goal to reach. This is where the Student Outcomes (SOs) and Student Learning Outcomes (SLOs), depending on the accreditation body, come into play (ABET, 2016; Burt et al., 2013). Different accreditation bodies use different levels of specificity in their standards. Some detail specific skills, courses, or assignments that students complete, while others simply provide an end goal and let the program decide how best to achieve it (Burt et al., 2013).

The two accreditation bodies chosen for this research are ABET and ACCE. ABET is the leading accreditation body for engineering and technology, with 247 accredited undergraduate Civil Engineer programs (ABET, 2017c). The USAF 32E career field requires ABET accreditation for engineering degrees (Department of the Air Force, 2016). In 2000, ABET published revised criteria aimed at learning outcomes (Prados, Peterson, & Lattuca, 2005). The new standards are aimed at continual improve from engineering programs to better prepare students for success in their field. ACCE is the largest construction management accreditation body, with 76 accredited undergraduate programs (Marshall et al., 2017).

Both ABET and ACCE have adopted broad student outcomes that describe levels of understanding, partially based on Bloom's Taxonomy (Burt et al., 2013). Bloom's Taxonomy is a framework for understanding educational goals and outcomes (Anderson & Krathwohl, 2001; Bloom, 1969). This framework describes six categories: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. These categories are placed in order of complexity; for example, comprehension of a subject requires knowledge of it, and each subsequent category is built from the previous ones. The Taxonomy is shown in Figure 2.

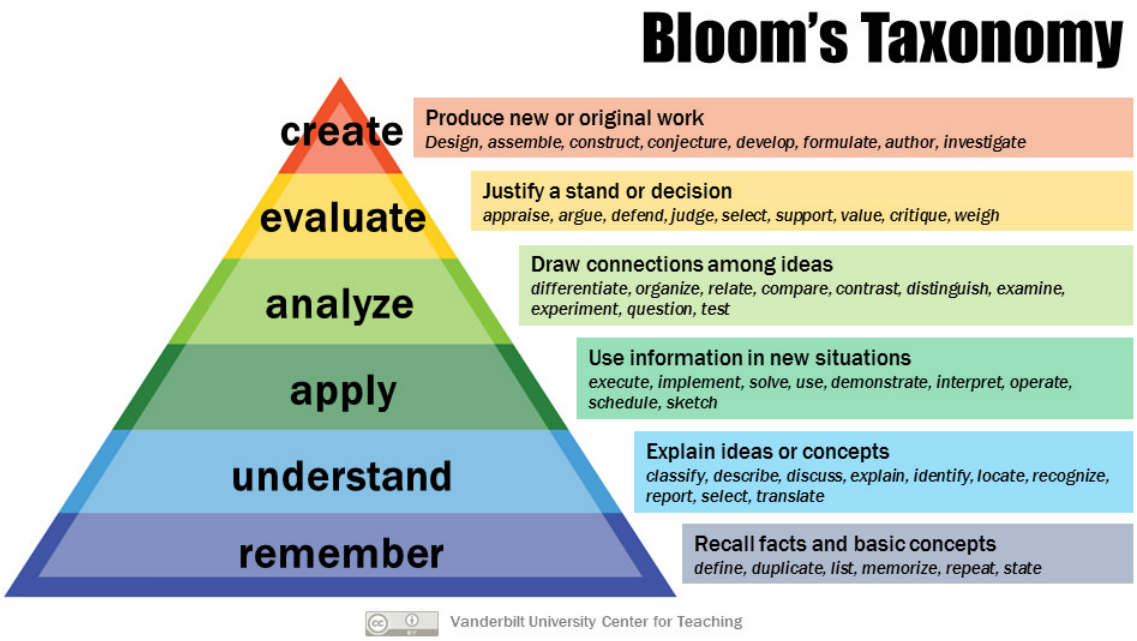


Figure 2: Bloom's Taxonomy, image courtesy of Vanderbilt University Center for Learning (Armstrong, 2017)

Student outcomes are often judged from this standard, written with one of the six categories to describe what level of emphasis is placed on the specific outcome (Burt et al., 2013). ACCE has called out Bloom's taxonomy specifically in their review of new Student Learning Outcomes. They use the following as their standard:

- Remembering: The lowest level of the taxonomy, remembering, requires students to do very little with the information they are learning. They may be asked to recall, list, or name an idea or concept.
- Understanding: At the next level, students demonstrate that they understand the content by explaining, summarizing, classifying, or translating the given information.
- Applying: At the application level, students begin to put the information they are learning into context. Here they are able to integrate ideas across multiple situations, or utilize the content in a new way.

- Analyzing: When students are presented with analysis tasks, they begin to develop higher order thinking. They may be asked to compare and contrast or take a concept and break it into parts to explore the relationships present.

- Evaluating: At this stage, students are asked to judge an idea. This may involve predicting, experimenting, critiquing, or making an argument from evidence.

- Creating: At the highest level, students are producing new ideas or products that integrate the knowledge they have gained. When students are involved in creating new artifacts, they are actively engaged in the subject matter (Burt et al., 2013).

By using this standard, someone can look at the accreditation criteria to see what level of emphasis is placed on a specific subject or learning outcome. The accreditation body clearly defines what the educator must pass on to the student, without defining how that is done (Huitt, 2011). This evaluation and organization of educational objectives is directly correlated to what students should know after graduating from a given program.

Significant research has been done on the effects of mismatch between a person's schooling and their career (Robst, 2007). The research on degree type mismatch shows that there are varying negative effects when a person is working outside of their degreed area of study. The paper focused specifically on economic costs and return on investment, indicating that a person with degree mismatch was more likely to earn less than a similarly educated person who had a matched degree. This effect is higher for more technical degrees, as the person will learn more occupation specific skills in their degree (Robst, 2007). While there may not be a financial difference at stake for CE officers, the skills transfer of working in a mismatched job correlate with a return on investment.

Higher education provides society many things, from highly skilled professionals to well-balanced citizens. To see how to connect the education to the profession, an understanding of what the US Air Force requires of its Civil Engineer officers must be established.

Roles and Responsibilities of USAF Civil Engineer Officers

Air Force Civil Engineer officers serve many roles, from deployed locations to garrison bases in the US and abroad. The Career Field Education and Training Plan (CFETP) describes a wide variety of capabilities that CE units perform for the Air Force (Department of the Air Force, 2016). Strategically, CE officers perform duties in support of the air base and commander, providing a safe and secure base with the infrastructure for all missions (Green, 2016). According to Air Force doctrine and the CFETP, CE units are responsible for all or part of the capabilities in Table 2.

Table 2: CE Strategic capabilities: adapted from USAF CFETP for CE Officers (Department of the Air Force, 2016)

CE Strategic Capabilities	
General engineering support for deployed units	Emergency repair of air bases
Base denial activities	Develop and execute survivability actions and base recovery after attack
Plan, budget, construct, operate, maintain, and repair of: Real Property, Utility Systems, Facilities, Military Family Housing, and Real Estate	Fire prevention and protection
Aircraft crash rescue	Disaster preparedness of air base for Nuclear, Biological, Chemical, and Conventional attack
Explosive Ordinance Disposal	Design
Prepare plans and specifications for contracts	Contract Inspection
Funds Management	Environmental protection and improvement

Within this strategic view, CE officers' roles vary widely depending on the unit type and location, personal qualification, and other factors. Some of the duties involve highly specialized or militarized actions like Emergency Response and Explosive Ordinance Disposal which require extensive training (Department of the Air Force, 2016). The largest portion of the duties, however, revolve around the life-cycle planning and executing of construction, maintenance, and repair projects for built and natural infrastructure. CE officers can be responsible for determining requirements, establishing plans and designs, and direct operations, maintenance, repair, alteration/addition, and construction of infrastructure. This includes budgeting, material and personnel planning, land use and environmental planning, as well as coordinating actions with other units and agencies. Officers must also act as technical representatives and consultants for the base (Department of the Air Force, 2016).

As mentioned in Chapter I, 32E's are required to have an architectural or engineering degree. This requirement allows the officers to perform functions listed in the CFETP pertaining to the design and execution of infrastructure and utility projects (Department of the Air Force, 2016). These degrees focus on the technical aspects of CE officer's duties, reducing the overall training required for new officers. The degree selection includes many of the specialties used in facility and infrastructure construction, like civil, electrical, and mechanical engineering.

In his 2016 graduate thesis, Captain Brian Greszler performed a Jobs Analysis for CE CGOs in deployed environments, working to catalogue and test the Tasks and Knowledge, Skills, and Abilities (KSAs) required for CE CGOs (Greszler, 2016). The thesis provided a list of skills that CGOs should have for the contingency environment.

He then tested CE CGOs to see what skills they did have, in order to see if there was a gap in knowledge. He highlighted a need for changes in contingency training for CE CGOs.

All CE officers are required to attend WMGT 101 Air Force Civil Engineer Basic Course, which provides officers with the basic structure, core competencies, processes, and leadership of Air Force CE (AFIT, 2018b). The course includes instruction in CE functions, project management, and technical basics in mechanical, electrical, and civil engineering to ensure that officers have "technical knowledge needed to complete infrastructure activities at home station and in a contingency environment."

Besides WMGT 101, the CFETP requires CE officers to receive training in specific contingency skills with Home Station Training, Computer Based Training, and completion of the Silver Flag exercise (Department of the Air Force, 2016). This required training includes training and experience for CE officers in a variety of skills, largely focused on leadership, communication, and the deployed mission.

The CFETP includes a list of recommended training courses from the CE School and timeframes or positions to assist an officer in their professional development (Department of the Air Force, 2016). The CFETP also includes a table in the Appendices that lays specific development levels and target completion periods with "required knowledge areas, training courses, and core competencies the CE officer is expected to demonstrate." This table is meant to be used as a guide to ensure that all officers meet basic goals. A total of 14 development levels are listed, across three target completion points.

Civil Engineer officers are able to take courses in a variety of management and technical subjects provided by the Air Force Institute of Technology (AFIT) Civil Engineer School. A variety of subjects are available and often focus on specific duties that officer, enlisted, and civilian personnel perform (AFIT, 2018a). Some courses are required for specific duties, like WMGT 410 Readiness and Emergency Management (REM) Flight Commanders Course which is required for all REM flight chiefs and superintendents (AFIT, 2018c). Other courses are optional, and thus require time from the student and their supervisor to dedicate to the training.

Civil Engineering versus Construction Management

To review the CE officer education requirements, two degrees will be compared: one allowed for new accessions and one not allowed. A Bachelor's of Science in Civil Engineering will be compared to a Bachelor's of Science in Construction Management. These two degree types both have similar origins and similar application in the planning and executing of capital construction projects (Abudayyeh, Russell, Johnston, & Rowings, 2000).

Construction Management degrees grew from Civil Engineering programs in the 1960s and 1970s (Guggemos & Khattab, 2016). Civil Engineers and Architects were typically used to oversee construction projects, but as construction became more complicated, the need for specific construction managers became clear. The technical aspects of design were being left to the engineers while managers would coordinate a growing number of specialties to effectively implement the plans and specifications. The needs of highly technical projects demanded highly skilled Engineers, Architects, and

Managers in the construction process, rather than individuals attempting to fill all of those roles.

The US Department of Labor (DoL), Employment and Training Administration (ETA) sponsors a system called O*NET (Occupational Network), which provides information on a wide variety of career fields within the US (National Center for O*NET Development, 2017). This system is based on a database with responses collected from workers in each occupation. O*NET data for Civil Engineers and Construction Managers shows different tasks, skills, and abilities that each profession requires. According to O*NET, Civil Engineers:

> Perform engineering duties in planning, designing, and overseeing construction and maintenance of building structures, and facilities, such as roads, railroads, airports, bridges, harbors, channels, dams, irrigation projects, pipelines, power plants, and water and sewage systems (ONET, 2017b).

Similarly, O*NET states that Construction Managers:

> Plan, direct, or coordinate, usually through subordinate supervisory personnel, activities concerned with the construction and maintenance of structures, facilities, and systems. Participate in the conceptual development of a construction project and oversee its organization, scheduling, budgeting, and implementation. Includes managers in specialized construction fields, such as carpentry or plumbing (ONET, 2017a).

The comparison of the two careers shows a marked similarity in required work activities and detailed work activities, shown in Appendix A (ONET, 2017a, 2017b).

Abudayyeh et. al. talk specifically about the differences in Construction Management and Construction Engineering Management (CEM), which is still usually a subset of Civil Engineering, claiming that the CEM degree focuses more on the math, science, and engineering, while the CM degrees focus on construction techniques, engineering technology, and management (Abudayyeh et al., 2000).

Comparative analysis has been performed on Construction Management industry and educator's views of key skills for graduating students (Farooqui & Ahmed, 2009). This study shows that there exists difference between the two; industry professionals ranked skills like knowledge of contract documents and listening ability/ giving attention to details higher while educators ranked knowledge of construction operations higher. This shows that, even with close ties from industry, education must still work to incorporate the right balance of soft and technical skills to match the needs of the workforce it is designed to benefit (Farooqui & Ahmed, 2009).

The architecture/engineering degree requirement for CE officers is meant to increase the capability of the force and allow officers to start with a strong technical base on which to build the other necessary skills and abilities (Department of the Air Force, 2016). As the roles and responsibilities for Civil Engineer Squadrons change, these technical degrees may be providing less benefit compared to specialized management degrees like Construction Management.

Survey Technique

The Delphi method of study was developed by the RAND Corporation to provide a consensus result using a smaller numbers of experts rather than a large random sample from the population of interest (RAND Corp, 2017). The method requires the panel of experts to anonymously respond to a series of questions and subsequently receive feedback about the groups' responses. This feedback allows the experts to anonymously analyze the group's responses in comparison to their own (Gupta & Clarke, 1996; RAND Corp, 2017; Rowe & Wright, 1999). When performed in a cycle of questions and

responses, the experts will converge on a consensus response. Originally, this method was used to predict future impact of new technology, but has been adapted for more diverse uses since its creation in the 1950s (RAND Corp, 2017). The Delphi method, along with other structured group procedures, has been shown to outperform other group procedures such as statistical and standard interacting groups (Rowe & Wright, 1999). There is growing support for the use of the Delphi method to allow researchers to reach a consensus on a topic that has confounding factors (Hallowell & Gambatese, 2010).

Summary

Higher education fills needs from society and the professional workforce. The goals of education are two-fold: educate people in the skills needed to better society and educate professionals in the skills needed for an industry. The construction industry has changed significantly over the last century, requiring professionals to fill technical management roles outside of the engineering field. Higher education has responded to this with the Construction Management field, educating people to have technical knowledge of construction practices, business knowledge of the industry, and social knowledge of management.

USAF CE has evolved in the last three decades, moving from design-centered engineer units to technical management units focused on work execution rather than in-house design. While the roles of civil engineers have changed, the AF educational requirements have not. This research aims to identify the operational skills needed by CE officers and relate them to higher education standards.

III. Methodology

Introduction

Two methodologies were used to collect and analyze data to study the effectiveness of the degree requirements for the 32E (USAF Civil Engineer) career field. A Delphi study was conducted to provide a consensus list of skills for Civil Engineer (CE) officers, and an accreditation outcome analysis was conducted for both Civil Engineering and Construction Management bachelor's degrees. Together, these two methods will produce results that will show how the current education requirements match the identified skills needed for CE Company Grade Officers (CGOs).

Theory

The Delphi methodology will be used for the survey portion of this study. A Delphi study uses a small group of experts and attempts to capture their knowledge and experience in a given field to provide consensus (Gupta & Clarke, 1996). Because there are so many different backgrounds and career paths within USAF CE, there exists a wide range of experience. This range, coupled with the changing locations and duties of CE officers, make a Delphi study an ideal choice for the collection of data for this research. With the analysis of how degree programs emphasize specific skills, the survey results will show how specific undergraduate degrees prepare their graduates for work in the CE career field.

Method 1 – Delphi Study

A Delphi study was conducted using subject matter experts in the 32E career field, aimed at providing a consensus list of skills for company grade officers (CGOs) in the same career field. The study relied on a panel of experts to answer a series of questions and receive anonymous feedback on the group responses. The subject matter experts used in this study were US Air Force CE officers, with at least 6 years of experience in the career field in a variety of different areas. A typical Delphi study uses 8-16 panelists, depending on a number of factors (Hallowell & Gambatese, 2010). The team was interested in using 8-12 respondents to ensure an adequately broad but responsive panel.

Resources

The survey was conducted using SurveyMonkey™ to provide anonymity to the respondents. Email correspondence was used to communicate with all participants on survey details, but no results were collected via email. All participants had computer and email access via the USAF network and/or home computers.

The major resource used for this study was the participants. First, the researcher gathered 12 experts from the CE career field. All experts were prequalified prior to the start of the survey, based on at least six years of CE experience in multiple areas. All potential panelists were contacted personally by one of the researchers to get agreement to participate and conduct screening.

Since the research was focused on the skills of CGO's, potential panelists were screened on experience and recency of working in a Civil Engineer Squadron. While duties like staff, training, and administration are important for the career field and still

valued by the researcher, they are irrelevant for the study. The research team wanted to ensure that respondents had recent and direct experience performing and supervising CE duties. The researchers also wanted experts who had experience beyond the first six years of being CE officers, filling a variety of roles within different units across the USAF CE portfolio. This focused the research team on officers in the ranks of Captain to Colonel, O-3 to O-6, where the Captains had at least six years and three duty assignments. As part of the first survey, each respondent was asked to provide answers on their experience to ensure that the panelists covered the broad spectrum of CE duties. The responses are provided in Chapter IV.

A Likert-type scale was chosen as the primary method of response. This scale allows the direct measure of attitude regarding a specific subject and allows a degree of opinion to be used for each response, which assists in distinguishing relative appeal (McLeod, 2008). The Likert scale was developed specifically for surveys aimed at respondent's attitudes and opinions, and thus matched the goals for this study. A comment field was also available for all surveys for additional feedback on question material.

The study was performed under Institutional Review Board (IRB) exemption.

Process and Procedures

The first survey rated 33 skills and provided a weighted average ranking. From the ranking, the skills were broken into six categories. The second survey rated the categories and provided a weighted average ranking. Consensus was reached after the second survey, so no additional surveys were used.

Survey #1

A list of skills was compiled for the panelists to score. Initially, the research team tried to use the different skills from the Department of Labor Occupational Network (O*NET) knowledge, skills, and abilities from both Civil Engineer and Construction Manager careers. The two lists were so similar, as described in Chapter II, they would show little differentiation between the two career fields. A list of 33 skills was then created from accreditation requirements. This list was based on the ACCE accreditation requirements for Construction Management degrees and ABET accreditation requirements for Civil Engineer degree. ABET supplements their requirements by using the American Society of Civil Engineers (ASCE) as the professional body to write and review the CE accreditation Student Outcomes (ASCE, 2016).

Each accreditation body had a list of Student Outcomes, ABET, or Student Learning Outcomes, ACCE, that describe what each student should be capable of after graduating. The two lists were compared and outcomes with similar skills were matched. While many of the outcomes were not direct matches, certain concepts or ideas were matched to allow the research team to provide a concise list for survey. An example of this is shown with the following two standards, one from each degree. ACCE standard 10: Apply electronic-based technology to manage the construction process. ABET standard (k): Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. These two standards do not use the same language on the surface, but deal directly with using new tools and technology to solve professional problems. The complete list of skills and comparisons is shown in Appendix B, Table 12. Once paired skills were identified, a single list was created to include all of the

individual skills from both degrees. The accreditation outcomes were then truncated to meet the needs of a survey. The final list for survey #1 can be seen in Table 3.

Table 3: Potential CE Officer Skills List given to Delphi study participants

Potential CE Officer Skills
Understanding of Differential Equations
Understanding of Calculus Based Physics
Design and conduct experiments
Analyze and interpret data
Engage in life-long learning, professional licensure
Analyze methods, materials, and equipment used to construct projects.
Understand construction quality assurance and control.
Analyze issues pertaining to ethics
Create oral presentations
Create written presentations
Apply skills as member of multidisciplinary team
Technology
Design engineering
Project safety planning
Project cost estimating
Project scheduling
Analyze construction documents for planning and management of construction processes
Risk management
Accounting and cost control
Construction project control processes
Project management
Business
Public policy
Leadership and management
Structural engineering
Environmental and water resources engineering
Transportation engineering
Geotechnical engineering
Hydraulics and hydrology engineering
Surveying
Mechanical systems
Electrical systems
Plumbing systems
Other: Please Specify

The survey used a seven-response Likert scale, from 1 to 7. This scale allowed the respondents to use their own experience to rate and differentiate each skill. A neutral option, corresponding to 4, was used to keep respondents from having a forced response (McLeod, 2008). The first question posed to the respondents is shown in Figure 3.

1. On a scale from 1 (Extremely Unlikely) to 7 (Extremely Likely), please rate how likely each skill is to be needed by a Lieutenant or junior Captain in the 32EXX career field. By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

1-Extremely Unlikely	2-Very Unlikely	3-Unlikely	4-Neutral	5-Likely	6-Very Likely	7-Extremely Likely

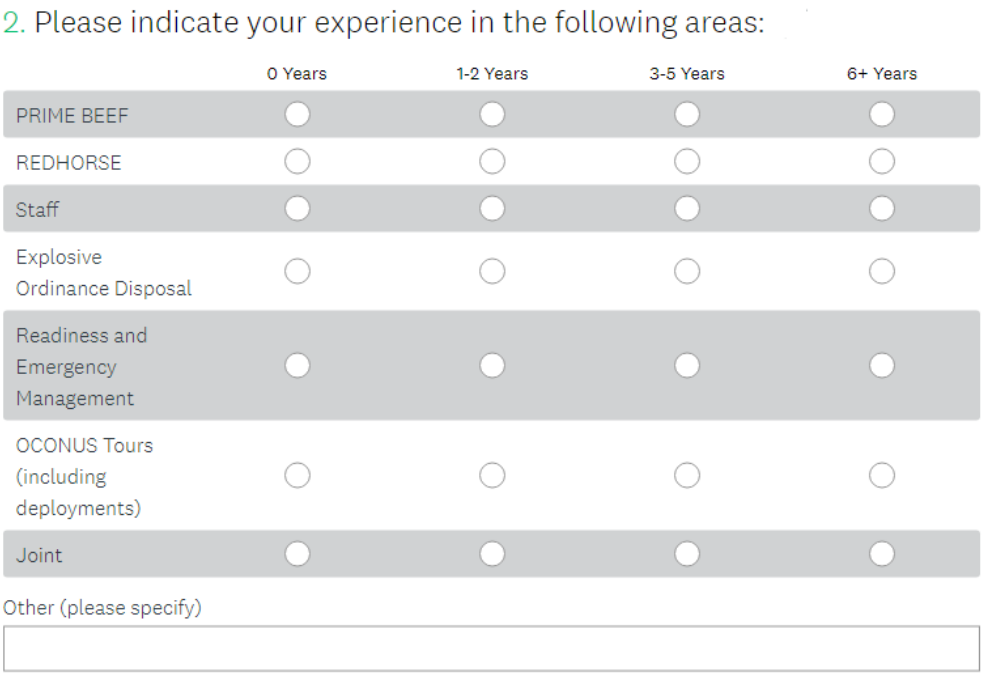
Figure 3: Screenshot showing Survey #1 Question #1

The second question was aimed at determining experience in a variety of areas, and used a multiple choice format to allow respondents to identify how much time they had spent in specific USAF CE areas. The respondents were given 4 choices: 0 years, 1-2 years, 3-5 years, and 6+ years. These choices were given to show a relative level of experience from none, low, moderate, to high. The second question is shown in Figure 4.

In addition to these two questions, a comment area was included to ensure each respondent felt their opinion was properly conveyed and allow for questions or concerns to be raised. All comments will be included in Appendix D.

The survey link was sent via email to each respondent with instructions and additional survey information, including background on the Delphi methodology and the strategic importance of education. Respondents were initially given 10 days to complete

the survey, but after an error in the survey programming that prohibited the panelists from responding was identified, a five day extension was given. Two days prior to the survey deadline a reminder email was sent all panel member reminding them to take the survey. The emails are located in Appendix C.



2. Please indicate your experience in the following areas:

	0 Years	1-2 Years	3-5 Years	6+ Years
PRIME BEEF				
REDHORSE				
Staff				
Explosive Ordinance Disposal				
Readiness and Emergency Management				
OCONUS Tours (including deployments)				
Joint				

Other (please specify)

Figure 4: Screenshot showing Survey #1 Question #2

The results of the first question were analyzed using a weighted average to show the relative importance of each skill to the respondents. Weighted average was calculated for each skill by multiplying the number of responses by their relative importance, divided by the total responses. $Weighted\ Average = \frac{Sum\ of\ Weighted\ Responses}{Total\ Responses}$. For this question, that meant adding each response rating, from 1 to 7, then dividing by the number of responses. The results were analyzed using a weighted average response to show how the group as a whole rated the skills. The averages were then ranked from

highest to lowest. Because the Delphi method requires a feedback loop, the weighted averages and rankings were sent to participants with the second survey. Results and analysis are available in Chapter IV.

Survey #2

After analyzing survey #1 results, the list of 40 skills were used to form the following six categories: Officership, Construction Management, Project Management, Engineering Design, Technical Skills, and General Management. Management encompasses both PM and CM, and Project Management encompasses Construction Management. The research team created distinct categories that lined up with specific areas of study or practical knowledge. These categories show distinction between skills of similar fields, like project and construction management, although many skills overlap. Skills like cost estimating and scheduling would be used by both CM and PM, but specific skills like Mechanical, Electrical, and Plumbing systems would only be taught in Construction Management. Certain skills could be shifted, but the survey will show how these management skills compare with the Officership and Engineering Design categories. The categories are meant to allow the Delphi panelist to show how likely the specific skill sets would be needed for CGOs. Appendix B, Table 13 shows the 40 skills broken into categories.

The participants were asked to use the same Likert scale from the first survey to rate the categories. This was done to allow comparison of the rating between the individual skills from survey #1 to the categories from survey #2. The question posed to the panel member is shown in Figure 5.

The survey question included examples for each category, to ensure the respondents had a similar definition for the terms, but emphasized that the list was not exhaustive of what could be in that category. The categories and examples shown to survey participants are shown in Figure 5.

Again, the survey link was sent via email to each respondent with the new instructions along with the results from survey #1 question #1. Respondents were given eight days to complete the survey. The research team chose eight days to ensure that the survey was complete prior to the December holiday season. Three days prior to the survey completion a reminder was sent to encourage all panel member to take the survey. The emails are located in Appendix C.

The results of the survey were analyzed using a weighted average to show the relative likelihood of CE CGOs needing the skills in each category, similar to survey #1. The panelists were then given the ranking of weighted averages to complete the feedback loop for the Delphi method. The results from this survey are available in Chapter IV.

Consensus will be determined by comparing the category ranking of the two surveys. The percent difference of weighted average rating will be measured for any categories that do not match. Percent difference is defined as the difference between two values divided by the average of the two values. Percent difference is used when both values have the same meaning and there is not a "correct" value (Illinois State University, n.d.). If the deviation is less than 10%, consensus has been reached (Hallowell & Gambatese, 2010). The Delphi portion of the study was concluded after two surveys because a consensus had been reached. $\% \, Difference = \frac{Value\ A - Value\ B}{(Value\ A + Value\ B)/2}$.

1. After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

	1-Extremely Unlikely	2-Very Unlikely	3-Unlikely	4-Neutral	5-Likely	6-Very Likely	7-Extremely Likely
Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	○	○	○	○	○	○	○
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	○	○	○	○	○	○	○
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	○	○	○	○	○	○	○
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	○	○	○	○	○	○	○
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	○	○	○	○	○	○	○
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	○	○	○	○	○	○	○

Figure 5: Screenshot showing Survey #2 Question

Method 2 – Accreditation Outcome Analysis

To compliment the Delphi study, an accreditation review was conducted of the two degree programs of interest, Civil Engineering and Construction Management. This review was based on the skills derived from the Student Outcomes, ABET, and Student Learning Outcomes, ACCE, from the Delphi study surveys. The analysis includes comparing the degree requirements to find similarities and major differences.

Resources

The resources required to complete the curriculum review were the skills list used in Survey 1, including the accreditation standards that are publically available, and the Bloom's Taxonomy. Bloom's taxonomy was used to create a percentage rating scale to show how each skill is emphasized in the two degree programs.

Process and Procedures

First, a scoring model was created to show a percentage score for each level of understanding. This scoring model was based on Bloom's taxonomy and used the verbs in the SO/SLO to connect a specific level of understanding. The taxonomy was rated to show a specific score for each word. A ranking system was needed to show the similarity between Evaluating and Creating, which are require a very similar level of understanding and are even switched in different versions of the taxonomy (Huitt, 2011). The scale shows these two as being very close, while the other categories are spread more evenly. The model uses the terminology from Bloom's taxonomy to equate how much a program emphasized a skill. The model is shown in Table 4.

Table 4: Scoring model for accreditation review

Required Level of Educational Outcome	Percentage Score	Notes
Remembering	10	Requires very little mastery of material beyond remembering what is available.
Understanding	30	Requires a student to explain a concept beyond simple repetition.
Applying	50	Shows a student's ability to put a concept they are learning into context.
Analyzing	70	Shows an ability to see a subject from multiple perspectives and/or break it down.
Evaluating	90	Shows an ability to experiment or test ideas and judge them based on their merits. Either the highest or second highest educational outcome.
Creating	100	Shows a complete mastery by integrating the information from a subject with context to synthesize something new.

Next, the CE and CM accreditation SO/SLOs were reviewed to see how each of the skills were emphasized. This was done using the accreditation terminology and the model created. Each skill was given a score based on verbiage in the accreditation standard. If a skill was not listed in the accreditation requirements for a degree, it was given a zero. This may not reflect how individual institutions structure their classes, as deeper understanding in certain areas may be emphasized in each program, but this analysis was focused on the accreditation standards. The goal of the research was to come up with a general understanding of how much is required by the accreditation bodies for CE and CM.

Summary

The methods described in this chapter detail how the accreditation requirements for CE and CM degrees correspond to the needs of the USAF 32E career field. Both the Delphi study and the outcome analysis will combine to the show what skills are needed and how the degrees emphasize those skills. The survey results and analysis are shown in the next chapter, followed by conclusions and recommendations in Chapter V.

IV. Analysis and Results

Chapter Overview

This chapter will provide the analysis of the two surveys forming the Delphi study and accreditation outcome review results. There will be a description of the responses for both questions in survey #1, including analysis and a description of how the results of survey #1 were used in survey #2. The responses from survey #2 will then be analyzed. The accreditation standards for Civil Engineering (CE) and Construction Management (CM) degrees will be scored to show the emphasis and discussed using the scoring model developed in Chapter III. A final summary show links between skills and degree program.

Analysis

After the data was collected using the Delphi study detailed in Chapter III, the surveys were analyzed according to the methods detailed in previous chapters. Because of the feedback loop required for the study, results were shared to study participants and incorporated in subsequent surveys.

Survey #1

The first survey results are shown in Table 5. A total of nine participants responded to this survey. This includes all responses to the initial list of skills rated by the study participants, including all written-in responses, which were included at the bottom of the survey. The respondents could write in up to five "Other" skills and rate them on the same scale. Since they were not available to all respondents, they are excluded from the ranking, but the scores for each are shown. The table includes the

average response, which was sent with survey #2 and used to rank the skills. The rank shows the group determination of which skills are most likely to be used by 32E CGOs. Please note, all fields rated by 0.00% of respondents were replaced by a "-" to make the table easier to read.

Table 5: Skill rating by Delphi study participants, Results from Survey #1 Question #1

Rank	Skill	1	2	3	4	5	6	7	Total	Weighted Average
1	Create oral presentations	-	-	-	-	-	-	100%	9	7.00
1	Leadership and management	-	-	-	-	-	-	100%	9	7.00
3	Project management	-	-	-	-	11%	-	89%	9	6.78
4	Apply skills as member of multidisciplinary team	-	-	-	-	11%	11%	78%	9	6.67
5	Create written presentations	-	-	-	-	22%	-	78%	9	6.56
6	Project cost estimating	-	-	-	-	-	44%	56%	9	6.56
7	Analyze construction documents for planning and management of construction processes	-	-	-	-	11%	22%	67%	9	6.56
8	Understand construction quality assurance and control.	-	-	-	-	22%	11%	67%	9	6.44
9	Construction project control processes	-	-	-	-	33%	11%	56%	9	6.22
10	Project scheduling	-	-	-	-	11%	56%	33%	9	6.22
11	Analyze and interpret data	-	-	-	-	22%	33%	44%	9	6.22
12	Analyze issues pertaining to ethics	-	-	11%	-	11%	33%	44%	9	6.00
13	Analyze methods, materials, and equipment used to construct projects.	-	-	-	-	33%	44%	22%	9	5.89
14	Risk management	-	11%	-	-	11%	56%	22%	9	5.67
15	Engage in life-long learning, professional licensure	-	-	11%	-	22%	56%	11%	9	5.56
16	Accounting and cost control	-	11%	-	-	33%	56%	-	9	5.22
17	Plumbing systems	-	-	-	11%	78%	-	11%	9	5.11
18	Project safety planning	-	-	-	44%	11%	33%	11%	9	5.11
19	Electrical systems	-	-	11%	22%	33%	22%	11%	9	5.00
20	Technology	-	-	11%	33%	22%	22%	11%	9	4.89
21	Public policy	-	11%	11%	-	44%	33%	-	9	4.78
22	Mechanical systems	-	-	22%	11%	44%	11%	11%	9	4.78
23	Business	-	11%	11%	11%	44%	11%	11%	9	4.67
24	Transportation engineering	-	11%	11%	-	67%	11%	-	9	4.56

25	Design engineering	-	11%	11%	33%	11%	22%	11%	9	4.56
26	Environmental and water resources engineering	-	-	11%	44%	33%	11%	-	9	4.44
27	Structural engineering	-	11%	-	33%	56%	-	-	9	4.33
28	Geotechnical engineering	-	22%	11%	33%	33%	-	-	9	3.78
29	Hydraulics and hydrology engineering	-	22%	44%	11%	22%	-	-	9	3.33
30	Surveying	-	50%	25%	13%	13%	-	-	8	2.88
31	Design and conduct experiments	33%	22%	33%	-	11%	-	-	9	2.33
32	Understanding of Calculus Based Physics	56%	22%	22%	-	-	-	-	9	1.67
33	Understanding of Differential Equations	67%	22%	11%	-	-	-	-	9	1.44
	Articulating ill-defined problems,					11%			1	
	Course-of-Action (COA) Analysis for leadership to make decisions					11%			1	
	Joint Engineering Planning & Operations - 5					11%			1	
	Contracts & Contracting skills (Very Likely)						11%		1	
	Project programming (Very likely)						11%		1	
	Long range base planning (Very likely)						11%		1	
	CE/DoD Financial Systems (If not covered in the "Business" question) (Extremely likely)							11%	1	

The second question on survey #1 asked respondents to indicate their experience in the seven areas, with an option for “Other” areas. This question received eight responses, meaning one participant who responded to question #1 did not respond to question #2. This data shows that qualitatively, the respondents have experience in five of the six fields, with Explosive Ordinance Disposal (EOD) being the only one not represented. All EOD officers must go through an 8 month Initial Skills Training to get the necessary skills to work in their field, so this area has the least bearing on undergraduate education requirements. Results from question #2 are shown in Table 6.

Table 6: Experience of Delphi study participants, responses from Survey #1 Question #2

Field	0 Years	1-2 Years	3-5 Years	6+ Years	Notes
PRIME BEEF	0	1	3	4	Primary home station mission for CE. All participants with at least 1 duty station as PRIME BEEF, 4 with 6+.
REDHORSE	5	1	2	0	Most technical mission set for most officers. Most participants have 0 experience here, but 3 with at least 1 assignment.
Staff	2	1	4	1	Officers usually have to serve at least 1 tour on staff, generally as senior captains or majors. 75% of participants have this experience.
Explosive Ordinance Disposal	8	0	0	0	No qualified EOD officer participants.
Readiness and Emergency Management	2	5	1	0	REM is a subset of the PRIME BEEF mission, but not all officers have experience in this. 75% of study participants have this experience.
OCONUS Tours (including deployments)	0	2	4	2	Deployments often require more technical knowledge skills. All participants have OCONUS tours, either overseas duty stations or deployments.
Joint	6	1	1	0	25% of study participants have this experience.
AFIT GEM		1			Other – Shows completion of masters in Engineering Management.
Engineering Educator (Instructor at AFIT CE)			1		Other – Shows completion of masters in USAF related topic.
Engineering Education				1	Other – Shows significant post-graduate education, topic unknown.

Survey #2

In the second survey, the skills were broken down into six categories and survey participants were asked to rate how likely the category was to be used by CE officers. Seven panelists responded to this survey. The survey results are shown in Table 7. Please note, all categories rated by 0.00% of respondents were replaced by a "-" to make the table easier to read.

Table 7: Skill Category rating by Delphi participants, responses from Survey #2

Rank	Category	1	2	3	4	5	6	7	Weighted Average
1	Officership	-	-	-	-	-	14.29%	85.71%	6.86
2	Construction Management	-	-	-	-	14.29%	14.29%	71.43%	6.57
3	Project Management	-	-	-	-	14.29%	28.57%	57.14%	6.43
4	Technical Understanding	-	-	-	-	42.86%	42.86%	14.29%	5.71
5	General Management	-	-	28.57%	-	42.86%	14.29%	14.29%	4.86
6	Engineering Design	-	14.29%	14.29%	28.57%	28.57%	-	14.29%	4.29

It was determined that a consensus had been reached when the ranking of the skills categories based on survey #1 was compared to the survey #2 results, shown in Table 8. The two surveys showed very similar results, with two differences in the ranking of the six categories. Two sets of two categories did not match ranking between the two surveys. The first mismatch was between Project Management and Construction Management. In survey #1, Project Management received an average rating of 5.93 and Construction Management received a 5.36. In survey # 2, Construction Management received a 6.57 and Project Management received a 6.43, a difference of 0.14. The percent difference was calculated to be 2.15%. This is less than the 10%, and therefore not limiting consensus.

Table 8: Comparison of results from surveys #1 and #2

	Survey #1		Survey #2	
Category	**Rank**	**Weighted Average**	**Rank**	**Weighted Average**
Officership	1	6.1	1	6.86
Project Management	2	5.93	3	6.43
Construction Management	3	5.36	2	6.57
Technical Understanding	5	4.48	4	5.71
General Management	4	4.49	5	4.86
Engineering Design	6	3.51	6	4.29

The other mismatch between surveys was with General Management and Technical Understanding. For survey #1, General Management received a rating of 4.49 and Technical Understanding received a 4.48. For Survey #2, General Management received a 4.86 and Technical Understanding received a 5.71. The percent difference is 0.22%, less than 10% and therefore not limiting consensus. The two differences were not determined to limit consensus, and it was determined that a consensus was reached.

Results

After determining that consensus was reached on the skills, the next step was to determine how the two degree programs of interest place emphasis on those skills. This is accomplished using the scoring model created in Chapter III, which assigns a percentage score to the six verbs used in Bloom's Taxonomy and in each Student Outcome or Student Learning Outcome. The scores allow the research team to objectively compare a given degree program's emphasis of the skills. Table 9 shows the scoring of the CE and CM degree requirements. The table includes a color indication of the score as well, with darker colors indicating greater emphasis.

Note: for skills ranked 24 to 30, CE Student Outcomes require graduates to study four of these subjects, two for "Analysis" and two for "Design". The research team showed used 100 for "Design" to score all seven of these skills to indicate what areas are emphasized in the CE programs, but not necessarily what each graduate will have (ASCE, 2016). A similar case exists for skills 27 and 28 in the CM Student Learning Outcomes. ACCE requires students to have either Structural or Geotechnical Engineering (ACCE, 2014).

Table 9: Comparison of Delphi study results and undergraduate degree programs

Rank	Skill	Average Response	CE	CM
1	Create oral presentations	7.00	70	100
2	Leadership and management	7.00	30	50
3	Project management	6.78	30	100
4	Apply skills as member of multidisciplinary team	6.67	50	50
5	Create written presentations	6.56	70	100
6	Project cost estimating	6.56	30	100
7	Analyze construction documents for planning and management of construction processes	6.56	0	70
8	Understand construction quality assurance and control.	6.44	0	30
9	Construction project control processes	6.22	0	30
10	Project scheduling	6.22	10	100
11	Analyze and interpret data	6.22	70	0
12	Analyze issues pertaining to ethics	6.00	70	70
13	Analyze methods, materials, and equipment used to construct projects.	5.89	0	70
14	Risk management	5.67	0	30
15	Engage in life-long learning, professional licensure	5.56	50	50
16	Accounting and cost control	5.22	0	30
17	Plumbing systems	5.11	10	30
18	Project safety planning	5.11	0	100
19	Electrical systems	5.00	10	30
20	Technology	4.89	50	50
21	Public policy	4.78	30	50
22	Mechanical systems	4.78	10	30
23	Business	4.67	30	70
24	Transportation engineering	4.56	100	0
25	Design engineering	4.56	100	0
26	Environmental and water resources engineering	4.44	100	0
27	Structural engineering	4.33	100	30
28	Geotechnical engineering	3.78	100	30
29	Hydraulics and hydrology engineering	3.33	100	0
30	Surveying	2.88	100	50
31	Design and conduct experiments	2.33	100	0
32	Understanding of Calculus Based Physics	1.67	30	0
33	Understanding of Differential Equations	1.44	30	0

Table 10 shows the relative emphasis within each accreditation program for the 33 skills that were pulled from the Outcomes for both of the degree programs of interest. Tables 11 and 12 show the average emphasis scores for the degree programs based on the skills ranking and ratings.

Table 10: Average emphasis score for skill ranking ranges for CE and CM degrees

Skill Rating	CE	CM
1-10	29	73
11-20	26	46
21-30	77	26
31-33	53.3	0

Table 11: Average emphasis score for skill rating ranges for CE and CM degrees

Rating	Score Range	CE	CM
Extremely Likely	6.5 - 7	40	81.4
Very Likely	5.5 - 6.5	25	47.5
Likely	4.5 - 5.5	34	39
Neutral	3.5 - 4.5	100	20
Unlikely to Extremely Unlikely	0 - 3.5	72	10

Summary

The study results show that based on subject matter expert knowledge and experience, the two degree programs, CE and CM, both provide a broad base of skills that translate to the duties of CE officers. The Construction Management Student Learning Outcomes emphasize skills that are needed by CE CGOs more than the Civil Engineering Student Outcomes. The skills needed by officers in the CE career field are broad and encompass a variety of areas, with only six accreditation related skills ending with a weighted average below neutral (4.0).

V. Conclusions and Recommendations

Chapter Overview

This chapter will draw upon the results and analysis from previous chapters to provide conclusions and recommendations from the research. The conclusions from the research will be discussed, to include how the results and analysis play a part in the education of Civil Engineer (CE) officers, as well as the significance to the body of knowledge for CE officer education. Recommendations for action based on the research will be provided, to include areas for future research. Finally, there will be a summary to include closing comments.

Conclusions of Research

The purpose of the research was to close the gap between the education requirements of CE officers with the operational skills needed. A Delphi study and accreditation outcome analysis provided a tangible list of skills for CE Company Grade Officers (CGOs) and basis for comparison of Civil Engineering (CE) and Construction Management (CM) undergraduate accreditation standards.

Delphi Study

The Delphi study resulted in a list of 36 skills that a CE CGO is likely to need. The list has a weighted average ranking, indicating what skills are more likely to be needed, as determined by subject matter experts.

This survey also showed what areas are most needed by CE CGOs. The skills categories used in the second survey show that within a career field with broad mission objectives and duties, there exists a variety of needs. Individuals may use different skills,

but the areas of focus are clear. The 32E career field requires Officership first and foremost. The panelists rated these skills as the most likely to be needed in both surveys, including four of the top five skills from survey #1. What was clearly shown in both surveys: an officer's first responsibility is to lead and provide support for their personnel. The skills included in Officership had less to do with technical knowledge or operational ability, and more to do with communicating clearly while taking care of a team. This is consistent with the requirement for officers to complete special training as part of the United States Air Force Academy (USAFA), Reserve Officer Training Corps (ROTC), or Officer Training School (OTS) (Department of the Air Force, 2018). These training programs provide the skills needed for all officers, including military specific training and leadership experience.

The second conclusion from the survey results is the need for CE officers to be effective Project Managers. This category of skills was rated second highest in survey #1 and third highest in survey #2. No matter what specialty a CE officer is trained in, they must be able to lead teams in the successful completion of project-style work. Officers are often called upon to perform a variety of roles in the project management process. From large Military Construction (MILCON) projects, smaller troop training construction projects, and administrative organizations, CE officers are asked to perform duties on projects and must be adept in project management. The skills include many carry-overs to construction management, like cost-estimating, #6, scheduling, and risk management.

A third conclusion shown from the survey results is the difference between Construction Management and Engineering Design skills. The Delphi panelists responded far stronger to Construction Management skills, on average rating them a 5.36

in survey #1 and 6.57 in survey #2, indicating that CE officers are Likely to Extremely Likely to need those skills within their first six years. This is compared to the Engineering Design skills, whose average scores of 3.51 in survey #1 and 4.29 in survey #2 indicate that CE officers are Neutral to need those skills within their first six years. This difference aligns with examples cited earlier in this paper that show CE officers duties are shifting from design to management.

Accreditation Outcomes Analysis

The accreditation outcomes analysis resulted in emphasis scoring of the skills and comparison of Civil Engineering and Construction Management degrees. The following conclusions are drawn from Table 9, which shows the skill ratings and emphasis scores. First, Construction Management emphasizes skills that were rated highly by the Delphi panel. For the top 10 skills by weighted average rating, CM's average emphasis score was 73 as opposed to CE's average score of only 29. This indicates that the Construction Management SLOs emphasize the skills rated highly by the Delphi panel more than the Civil Engineering SOs.

While both degrees showed applicability by 32E officers, Construction Management standards focus on areas needed by CE officers, where Civil Engineering standards focus on skills that are less likely to be needed by CE officers. The CE standards emphasize skills that were concentrated in the middle rating. Table 12 shows that CE had an emphasis score of 100 for skills with a weighted average rating that equated to "Neutral" on the survey. For skills that equated to "Extremely Likely" and "Very Likely", CE had scores of 40 and 25, respectively. This indicates that the Civil

Engineering Student Outcomes do not emphasize the skills rated highly by the Delphi panel for the duties of a CE officers.

Significance of Research

This research provides a list of skills that CE officers are likely to need. The list shows the skills that Subject Matter Experts from the 32E career field see as likely to be needed by young CE officers. The list can be used to evaluate various education avenues or future training efforts. While there may be examples of other skills that individuals use in a different proportion, this list provides a basis for discussion and decision making. This research adds to the Body of Knowledge of skills analysis and education requirements for different careers.

Recommendations for Action

After collecting the data, analyzing the results, and coming to conclusions, the following are a list of recommended actions to further increase the effectiveness of CE officers and the units:

1. Accept Construction Management degrees for new accessions. The current CE Career Field Education and Training Plan (CFETP) requires an engineering or architecture degree, as discussed in earlier chapters. The data shows that ACCE accredited Construction Management degrees provide graduates with skills that match the needs of CE officers. While it could signal a shift in certain capabilities like design engineering, the change would acknowledge what duties CE officers are being asked to perform. Accepting

CM graduates would add vital skills to the career field. The current list of accepted degrees for CE officers includes a variety of different specialties like Architectural, Mechanical, or Industrial Engineering. Graduates from these degree programs learn additional skills through training programs and experience, and perform the same duties as officers holding a traditional CE degree. Adding Construction Management to the list of accepted degrees would increase the number of qualified graduates available for accession, and could improve the overall effectiveness of the career field.

2. Incorporate mandatory Project Management and Construction Management courses in 32E training. The results from both surveys are clear; besides skills developed as an officer, Project and Construction Management skills are very important and likely to be used by a 32E. While many young CGOs are able to get experience in these areas, the opportunities are inconsistent. These skills are not emphasized in traditional engineering degree programs, so the CE Schoolhouse classes like WMGT 422 Project Management, WENG 200 Scoping and Estimating, and WENG 400 Life-Cycle Cost Estimating could be made more available, or be mandatory, for officers with less than 6 years of experience. The training can bolster the experience officers get on the job and ensure that no matter what undergraduate degree an officer has, they have the proper tools to perform their duties.

3. Incorporate Project Management and Construction Management skills as part of USAF Academy Civil Engineering degree. The biggest pipeline for the 32E

career field is United States Air Force Academy (USAFA), specifically the Department of Civil and Environmental Engineering (DFCE). Of all graduates from WMGT 101 between June 2011 and Dec 2017, 188 of 809 graduates, just over 23%, were USAFA graduates with a degree in Civil or Environmental Engineering (personal communication, 8 February 2018). In order to produce the biggest change for 32E, changes to the CE curriculum could be made to incorporate mandatory classes in Project and Construction Management. Lt Col Robert Young, Head of the Construction Management Division of USAFA DFCE, identified four courses pertaining to the subject: CE 464 Architectural Design, CE 215 Computer Applications for Civil Engineers, CE 480 Project Management and Contract Administration, and CE 485 Construction Project Management (personal communication, 30 March 2017). Of those, only one is mandatory for graduation, CE 480, and two do not directly focus on Construction Management, CE 215 and CE 464 (USAFA/DFCE, 2016a, 2016b, 2017a, 2017b). The USAFA website includes two additional courses, CE 486 and CE 486x, titled Applied Construction Practices, that have course descriptions in line with some of the PM and CM skills (USAFA, 2017). In total, that shows that one required course and three optional courses cover Project or Construction Management within the course sequence. In order to increase the capabilities of the young CE officers, construction and project management emphasis could be significantly increased, to include courses in areas like cost estimating, scheduling, or construction risk/safety management.

Limitations of the Research

This research sought to develop a list of skills that a CE officer would likely need and compare that list with two degree programs. While the skills developed during undergraduate education are important and can lead to future success, they are only one part of an officer's tool set. Officers act as professional technicians, managers, and leaders, combining their education, training, and experience to reach the goals set in front of them.

This research limited the scope to explore only CE and CM. The researchers did not incorporate all degrees allowed by the CFETP and reviewed only accreditation requirements. The degrees issued by each institution incorporate different classes and programs choose how they will accomplish the SO/SLOs. Some programs may choose to emphasize more of one subject than another, while still meeting the overall accreditation standards.

Recommendations for Future Research

Along with recommendations for action, the research also presents areas for future research. These areas continue to build on the Body of Knowledge presented in this study and answer questions discovered while analyzing the data.

1. Perform similar analysis for different degrees. The skills list created with the Delphi study could be used to analyze more undergraduate degrees than Civil Engineering and Construction Management. Some options include the seven degrees accepted for new accessions from Chapter I, Project Management, and Business Management.

2. Perform skill rating survey with a large group of senior 32E officers to provide additional data for analysis. The Delphi study presented in this research allowed the research team to produce a list using a smaller study group. By reproducing a similar study with a large group, more statistical analysis could be performed.

3. Perform a Job Analysis of duties being performed rather than skills needed by CE officers. In order to get a complete picture of the jobs being performed by CE officers, a formal Job Analysis should be completed. The Job Analysis would provide senior leaders a complete picture of duties being performed. The Air Force organization responsible for Job Analysis, the Directorate of Intelligence, Operations, and Nuclear Integration/Occupation Analysis (AETC/A3/OA), only performs evaluation of officer career fields at the request of the Air Force Career Field Managers (AFCFMs) (Department of the Air Force, 2017). The AETC/A3/OA is not likely to fund or perform a Job Analysis. This presents an opportunity for future students. Performing an assessment of the duties would show how the officers are used and might provide a different perspective from the skills list done in this research. The Air Force and Civil Engineer communities could benefit from this deeper understanding.

Summary

The purpose of this research was to develop the understanding how the undergraduate degrees of interest compare to the skills CE CGOs need to succeed. The

research used a weighted average ranking of skills. The list of 40 skills was developed using a Delphi study to survey Subject Matter Experts on what skills CGOs would need. The results from that list were scored to determine how the accreditation standards for Civil Engineering and Construction Management degrees emphasized those skills. This analysis showed that, while graduates from both degrees learn skills needed to be CE officers, Construction Management degrees provide more emphasis on skills that are needed by 32Es. This conclusion led to a list of recommended actions and areas for further research.

Bibliography

Abbas, A., Din, Z. U., & Farooqui, R. (2016). Integration of BIM in Construction Management Education: An Overview of Pakistani Engineering Universities. *Procedia Engineering*, *145*, 151–157. https://doi.org/10.1016/j.proeng.2016.04.034

ABET. (2016). Criteria for Accrediting Engineering Programs, 2016 – 2017 | ABET. Retrieved August 30, 2017, from http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/

ABET. (2017a). A Network Of Experts | ABET. Retrieved August 13, 2017, from http://www.abet.org/network-of-experts/

ABET. (2017b). Accreditation Step by Step | ABET. Retrieved August 30, 2017, from http://www.abet.org/accreditation/get-accredited-2/get-accredited-step-by-step/

ABET. (2017c). Find an ABET-Accredited Program, Construction Engineering Bachelor. Retrieved July 19, 2017, from http://main.abet.org/aps/accreditedprogramsearch.aspx

Abudayyeh, O., Russell, J., Johnston, D., & Rowings, J. (2000). Construction Engineering and Management Undergraduate Education. *Journal of Construction Engineering and Management*, *126*(3), 169–175. https://doi.org/10.1061/(ASCE)0733-9364(2000)126:3(169)

ACCE. (2014). DOCUMENT 103 STANDARDS AND CRITERIA FOR ACCREDITATION OF POSTSECONDARY CONSTRUCTION EDUCATION DEGREE PROGRAMS. Retrieved from http://www.acce-hq.org/images/uploads/Document_103_050314.pdf

ACCE. (2017). Mapping SACS SLO with ACCE SLO and Course Learning Outcomes.

ACCE. (2018). About Industry. Retrieved January 20, 2018, from http://www.acce-hq.org/industry/about-industry/

AFIT. (2018a). The Civil Engineer School History. Retrieved January 25, 2018, from https://www.afit.edu/CE/page.cfm?page=548&tabname=Tab6A

AFIT. (2018b). WMGT 101 Air Force Civil Engineer Basic Course. Retrieved January 25, 2018, from https://www.afit.edu/ce/Course_Desc.cfm?p=WMGT 101

AFIT. (2018c). WMGT 410 Readiness and Emergency Management Flight Commanders Course. Retrieved January 25, 2018, from https://www.afit.edu/ce/Course_Desc.cfm?p=WMGT 410

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing : a revision of Bloom's taxonomy of educational objectives*. Longman.

Armstrong, P. (2017). Bloom's Taxonomy. Retrieved September 6, 2017, from https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

ASCE. (2016). ce_program_criteria_webinar_2016.

Bloom, B. S. (1969). *Taxonomy of educational objectives : the classification of educational goals.* Prentice Hall.

Burt, R., Batie, D., Burns, T., Fletcher, D., Harris, G., & Schmidt, J. (2013). Commentary on the ACCE Student Learning Outcomes. Retrieved from http://www.acce-hq.org/images/uploads/Commentaries_on_4-year_SLOs.pdf

Christofferson, J. P., Wynn, K., & Newitt, J. S. (2006). Assessing Construction Management Higher Education Strategies: Increasing Demand, Limited Resources, and Over-Enrollment. *International Journal of Construction Education and Research*, *2*(3), 181–192. https://doi.org/10.1080/15578770600906992

Culver, M. (2007). Civil EnginEEr Special Edition on CE Transformation Special Edition on CE Transformation Transforming the Way We Work. *Air Force Civil Engineer*, *15*(5), 1–12. Retrieved from http://www.afcec.af.mil/Portals/17/documents/About-Us/AFCE-Magazine/Archives/AFD-120926-124.pdf

Department of Education. (2003). Accreditation in the U.S. Retrieved August 13, 2017, from https://www2.ed.gov/admins/finaid/accred/accredus.html

Department of Education. (2017). Accreditation Agencies. Retrieved August 13, 2017, from https://ope.ed.gov/accreditation/agencies.aspx

Department of the Air Force. (2016). *AFSC 32EX Civil Engineer Officer*. Retrieved from http://static.e-publishing.af.mil/production/1/af_a4/publication/cfetp32ex/cfetp32ex.pdf

Department of the Air Force. (2017). BY ORDER OF THE SECRETARY OF THE AIR FORCE. Retrieved from http://static.e-

publishing.af.mil/production/1/af_a1/publication/afi36-2623/afi36-2623.pdf

Department of the Air Force. (2018). U.S. Air Force - Officer Process. Retrieved February 6, 2018, from https://www.airforce.com/how-to-join/process/officer

Farooqui, R. U., & Ahmed, S. M. (2009). KEY SKILLS FOR GRADUATING CONSTRUCTION MANAGEMENT STUDENTS – A COMPARATIVE STUDY OF INDUSTRY AND ACADEMIC PERSPECTIVES. *Construction Research Congress*, 1439–1448. Retrieved from https://ascelibrary-org.afit.idm.oclc.org/doi/pdf/10.1061/41020%28339%29146

Fortino, A. (2012). The Purpose of Higher Education: To Create Prepared Minds | The EvoLLLution. Retrieved August 13, 2017, from https://evolllution.com/opinions/the-purpose-of-higher-education-to-create-prepared-minds/

Green, T. S. (Director of C. E. (2016). United States Air Force Civil Engineers 2016 – 2036 Civil Engineer Flight Plan.

Greszler, B. S. (2016). *Air force institute of technology*. Air Force Institue of Technology.

Guggemos, A. A., & Khattab, M. (2016). The Future of Construction Education: Partnering with Industry. *Construction Research Congress*, 120–129. Retrieved from https://ascelibrary-org.afit.idm.oclc.org/doi/pdf/10.1061/9780784479827.013

Gupta, U. G., & Clarke, R. E. (1996). Theory and applications of the Delphi technique: A bibliography (1975–1994). *Technological Forecasting and Social Change*, *53*(2), 185–211. https://doi.org/10.1016/S0040-1625(96)00094-7

Hallowell, M. R., & Gambatese, J. A. (2010). Qualitative Research: Application of the Delphi Method to CEM Research. *Journal of Construction Engineering and Management2*, *136*(1), 99–107. https://doi.org/10.1061/ASCE̊CO.1943-7862.0000137

Huitt, W. (2011). Bloom et al.'s Taxonomy of the Cognitive Domain. Retrieved January 18, 2018, from www.edpsycinteractive.org/topics/cognition/bloom.html

Illinois State University. (n.d.). Percent Difference – Percent Error. Retrieved February 7, 2018, from http://www2.phy.ilstu.edu/~wenning/slh/Percent Difference Error.pdf

Marshall, J., Webb, D. E., Elhouar, S., Hauck, A. J., Arthur, J., Zoghi, M., … Ahmad, I.

(2017). American Council for Construction Education Programs. Retrieved from http://www.acce-hq.org/images/uploads/Programs_0429163.pdf

McLeod, S. (2008). Likert Scale | Simply Psychology. Retrieved January 18, 2018, from https://www.simplypsychology.org/likert-scale.html

National Center for O*NET Development. (2017). O*NET Resource Center - Overview. Retrieved August 7, 2017, from https://www.onetcenter.org/overview.html

ONET. (2017a). 11-9021.00 - Construction Managers. Retrieved January 18, 2018, from https://www.onetonline.org/link/details/11-9021.00

ONET. (2017b). 17-2051.00 - Civil Engineers. Retrieved January 18, 2018, from https://www.onetonline.org/link/details/17-2051.00#Credentials

Prados, J. W., Peterson, G. D., & Lattuca, L. R. (2005). Quality Assurance of Engineering Education through Accreditation: The Impact of Engineering Criteria 2000 and Its Global Influence. *Journal of Engineering Education*, *94*(1), 165–184. https://doi.org/10.1002/j.2168-9830.2005.tb00836.x

RAND Corp. (2017). Delphi Method | RAND. Retrieved June 5, 2017, from https://www.rand.org/topics/delphi-method.html

Robst, J. (2007). Education and job match: The relatedness of college major and work. *Economics of Education Review*, *26*(4), 397–407. https://doi.org/10.1016/J.ECONEDUREV.2006.08.003

Rowe, G., & Wright, G. (1999). The Delphi technique as a forecasting tool: issues and analysis. *International Journal of Forecasting*, *15*(4), 353–375. https://doi.org/10.1016/S0169-2070(99)00018-7

Sutton, B. Z. (2016). Higher Education's Public Purpose | Association of American Colleges & Universities. Retrieved August 13, 2017, from https://www.aacu.org/leap/liberal-education-nation-blog/higher-educations-public-purpose

USAFA. (2017). Civil Engineering Course Sequence. Retrieved from https://www.academyadmissions.com/wp-content/uploads/2012/05/Courses_CivilEngineering.pdf

USAFA/DFCE. (2016a). CE 464 Policy Fall 2016.

USAFA/DFCE. (2016b). CE 485 Policy F16.

USAFA/DFCE. (2017a). CE215 Policy S17.

USAFA/DFCE. (2017b). CE 480 Policies Spring 2017.

Appendix A - O*NET Knowledge, Skills, and Abilities for CE and CM

Work Activities
17-2051.00 - Civil Engineers

Importance	Work Activity	Work Activity Description
85	Making Decisions and Solving Problems	Analyzing information and evaluating results to choose the best solution and solve problems.
84	Getting Information	Observing, receiving, and otherwise obtaining information from all relevant sources.
80	Communicating with Supervisors, Peers, or Subordinates	Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.
77	Interacting With Computers	Using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information.
76	Evaluating Information to Determine Compliance with Standards	Using relevant information and individual judgment to determine whether events or processes comply with laws, regulations, or standards.
75	Thinking Creatively	Developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic contributions.
75	Updating and Using Relevant Knowledge	Keeping up-to-date technically and applying new knowledge to your job.
73	Organizing, Planning, and Prioritizing Work	Developing specific goals and plans to prioritize, organize, and accomplish your work.
73	Communicating with Persons Outside Organization	Communicating with people outside the organization, representing the organization to customers, the public, government, and other external sources. This information can be exchanged in person, in writing, or by telephone or e-mail.
71	Inspecting Equipment, Structures, or Material	Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects.
71	Analyzing Data or Information	Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts.
71	Establishing and Maintaining Interpersonal Relationships	Developing constructive and cooperative working relationships with others, and maintaining them over time.

70	Identifying Objects, Actions, and Events	Identifying information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events.
70	Coordinating the Work and Activities of Others	Getting members of a group to work together to accomplish tasks.
69	Developing and Building Teams	Encouraging and building mutual trust, respect, and cooperation among team members.
68	Provide Consultation and Advice to Others	Providing guidance and expert advice to management or other groups on technical, systems-, or process-related topics.
66	Processing Information	Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data.
66	Scheduling Work and Activities	Scheduling events, programs, and activities, as well as the work of others.
66	Monitoring and Controlling Resources	Monitoring and controlling resources and overseeing the spending of money.
65	Estimating the Quantifiable Characteristics of Products, Events, or Information	Estimating sizes, distances, and quantities; or determining time, costs, resources, or materials needed to perform a work activity.
65	Judging the Qualities of Things, Services, or People	Assessing the value, importance, or quality of things or people.
65	Guiding, Directing, and Motivating Subordinates	Providing guidance and direction to subordinates, including setting performance standards and monitoring performance.
64	Resolving Conflicts and Negotiating with Others	Handling complaints, settling disputes, and resolving grievances and conflicts, or otherwise negotiating with others.
63	Documenting/Recording Information	Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic form.
63	Coaching and Developing Others	Identifying the developmental needs of others and coaching, mentoring, or otherwise helping others to improve their knowledge or skills.
61	Drafting, Laying Out, and Specifying Technical Devices, Parts, and Equipment	Providing documentation, detailed instructions, drawings, or specifications to tell others about how devices, parts, equipment, or structures are to be fabricated, constructed, assembled, modified, maintained, or used.
60	Developing Objectives and Strategies	Establishing long-range objectives and specifying the strategies and actions to achieve them.
60	Training and Teaching Others	Identifying the educational needs of others, developing formal educational or training programs or classes, and teaching or instructing others.

59	Monitor Processes, Materials, or Surroundings	Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems.
59	Interpreting the Meaning of Information for Others	Translating or explaining what information means and how it can be used.
56	Staffing Organizational Units	Recruiting, interviewing, selecting, hiring, and promoting employees in an organization.

Work Activities
11-9021.00 - Construction Managers

Importance	Work Activity	Work Activity Description
90	Making Decisions and Solving Problems	Analyzing information and evaluating results to choose the best solution and solve problems.
90	Communicating with Supervisors, Peers, or Subordinates	Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.
84	Resolving Conflicts and Negotiating with Others	Handling complaints, settling disputes, and resolving grievances and conflicts, or otherwise negotiating with others.
81	Scheduling Work and Activities	Scheduling events, programs, and activities, as well as the work of others.
80	Getting Information	Observing, receiving, and otherwise obtaining information from all relevant sources.
80	Interacting With Computers	Using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information.
79	Organizing, Planning, and Prioritizing Work	Developing specific goals and plans to prioritize, organize, and accomplish your work.
77	Communicating with Persons Outside Organization	Communicating with people outside the organization, representing the organization to customers, the public, government, and other external sources. This information can be exchanged in person, in writing, or by telephone or e-mail.
77	Developing and Building Teams	Encouraging and building mutual trust, respect, and cooperation among team members.
76	Establishing and Maintaining Interpersonal Relationships	Developing constructive and cooperative working relationships with others, and maintaining them over time.

75	Evaluating Information to Determine Compliance with Standards	Using relevant information and individual judgment to determine whether events or processes comply with laws, regulations, or standards.
75	Interpreting the Meaning of Information for Others	Translating or explaining what information means and how it can be used.
74	Coordinating the Work and Activities of Others	Getting members of a group to work together to accomplish tasks.
73	Inspecting Equipment, Structures, or Material	Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects.
73	Documenting/Recording Information	Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic form.
72	Identifying Objects, Actions, and Events	Identifying information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events.
70	Monitor Processes, Materials, or Surroundings	Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems.
70	Estimating the Quantifiable Characteristics of Products, Events, or Information	Estimating sizes, distances, and quantities; or determining time, costs, resources, or materials needed to perform a work activity.
69	Updating and Using Relevant Knowledge	Keeping up-to-date technically and applying new knowledge to your job.
68	Analyzing Data or Information	Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts.
65	Processing Information	Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data.
64	Developing Objectives and Strategies	Establishing long-range objectives and specifying the strategies and actions to achieve them.
63	Guiding, Directing, and Motivating Subordinates	Providing guidance and direction to subordinates, including setting performance standards and monitoring performance.
62	Performing Administrative Activities	Performing day-to-day administrative tasks such as maintaining information files and processing paperwork.
61	Thinking Creatively	Developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic contributions.

60	Judging the Qualities of Things, Services, or People	Assessing the value, importance, or quality of things or people.
57	Coaching and Developing Others	Identifying the developmental needs of others and coaching, mentoring, or otherwise helping others to improve their knowledge or skills.
57	Monitoring and Controlling Resources	Monitoring and controlling resources and overseeing the spending of money.
56	Provide Consultation and Advice to Others	Providing guidance and expert advice to management or other groups on technical, systems-, or process-related topics.
50	Selling or Influencing Others	Convincing others to buy merchandise/goods or to otherwise change their minds or actions.
50	Performing for or Working Directly with the Public	Performing for people or dealing directly with the public. This includes serving customers in restaurants and stores, and receiving clients or guests.

Detailed Work Activities 17-2051.00 - Civil Engineers
Detailed Work Activity
Inspect facilities or sites to determine if they meet specifications or standards.
Estimate technical or resource requirements for development or production projects.
Recommend technical design or process changes to improve efficiency, quality, or performance.
Design systems to reduce harmful emissions.
Test characteristics of materials or structures.
Direct construction activities.
Estimate operational costs.
Survey land or bodies of water to measure or determine features.
Create graphical representations of civil structures.
Develop technical methods or processes.
Investigate the environmental impact of projects.
Explain project details to the general public.
Incorporate green features into the design of structures or facilities.
Prepare proposal documents.
Coordinate safety or regulatory compliance activities.
Evaluate technical data to determine effect on designs or plans.
Implement design or process improvements.
Analyze operational data to evaluate operations, processes or products.

Detailed Work Activities 11-9021.00 - Construction Managers
Detailed Work Activity
Negotiate project specifications. Manage construction activities. Develop operating strategies, plans, or procedures. Supervise employees. Prepare financial documents, reports, or budgets. Determine operational compliance with regulations or standards. Evaluate green operations or programs for compliance with standards or regulations. Direct facility maintenance or repair activities. Investigate industrial or transportation accidents. Estimate labor requirements. Prepare forms or applications. Implement organizational process or policy changes. Develop environmental remediation or protection plans. Develop procedures to evaluate organizational activities. Purchase materials, equipment, or other resources. Communicate organizational information to customers or other stakeholders. Communicate organizational policies and procedures. Analyze data to determine project feasibility. Estimate green project costs. Analyze forecasting data to improve business decisions. Model operational processes. Train employees on environmental awareness, conservation, or safety topics. Recruit personnel. Prepare operational budgets for green energy or other green operations. Develop sustainable organizational policies or practices.

Appendix B - Tables used in survey development

Table 12: Comparison of accreditation standards

Construction Management (ACCE)	Civil Engineering (ABET, ASCE)
	Math through differential equations
	Chemistry, calculus based physics
	Additional basic science
	Ability to design and conduct experiments, as well as to analyze and interpret data
	Ability to identify, formulate, and solve engineering problems
	Recognition of the need for, and an ability to engage in life-long learning, professional licensure
Understand construction risk management.	
Analyze methods, materials, and equipment used to construct projects.	
Understand construction quality assurance and control.	
Analyze professional decisions based on ethical principles.	Analyze issues in professional ethics
Create written communications appropriate to the construction discipline.	Ability to communicate effectively
Create oral presentations appropriate to the construction discipline	
Apply construction management skills as a member of a multidisciplinary team.	Ability to function on multidisciplinary teams
Apply electronic-based technology to manage the construction process.	Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
Create a construction project safety plan.	Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
Create construction project cost estimates.	
Create construction project schedules.	
Analyze construction documents for planning and management of construction processes.	
Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process	Explain basic concepts in project management, business, public policy, and leadership
Understand construction accounting and cost control.	
Understand construction project control processes.	
Understand the legal implications of contract, common, and regulatory law to manage a construction project.	Knowledge of contemporary issues
Understand the basic principles of sustainable construction.	Apply 4 technical areas of CE (structural, environmental, transportation, geotechnical, construction, water resources, hydraulics/ hydrology, surveying/ measurements)
Apply basic surveying techniques for construction layout and control.	
Understand the basic principles of structural behavior.	
Understand the basic principles of mechanical, electrical and plumbing systems.	

Table 13: Breakdown of Skill Categories used to analyze skill groupings

Skill	Category
Analyze construction documents for planning and management of construction processes	Construction Management
Understand construction quality assurance and control.	Construction Management
Construction project control processes	Construction Management
Analyze methods, materials, and equipment used to construct projects	Construction Management
Surveying	Construction Management
Plumbing systems	Construction Management
Electrical systems	Construction Management
Mechanical systems	Construction Management
Transportation engineering	Engineering Design
Design engineering	Engineering Design
Environmental and water resources engineering	Engineering Design
Structural engineering	Engineering Design
Geotechnical engineering	Engineering Design
Hydraulics and hydrology engineering	Engineering Design
Understanding of Calculus Based Physics	Engineering Design
Understanding of Differential Equations	Engineering Design
Accounting and cost control	General Management
Public policy	General Management
Business	General Management
CE/DoD Financial Systems	General Management
Create oral presentations	Officership
Leadership and management	Officership
Apply skills as member of multidisciplinary team	Officership
Create written presentations	Officership
Analyze issues pertaining to ethics	Officership
Engage in life-long learning, professional licensure	Officership
Articulating ill-defined problems,	Officership
Course-of-Action (COA) Analysis	Officership
Contracts & Contracting skills	Project Management
Project management	Project Management
Project cost estimating	Project Management
Project scheduling	Project Management
Risk management	Project Management
Project safety planning	Project Management
Joint Engineering Planning & Operations	Project Management
Project programming	Project Management
Long range base planning	Project Management
Analyze and interpret data	Technical Understanding
Technology	Technical Understanding
Design and conduct experiments	Technical Understanding

Appendix C – Group Emails Sent to Delphi Panel

Survey #1 – Email requesting responses

AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills (Response Requested by 17 NOV 17)

Mills, Joshua C 1st Lt USAF AETC AFIT/ENV <Joshua.Mills@afit.edu>

Tue 11/7/2017 10:01 PM

To:CHAMBERS MILLS, JOSHUA C Capt USAF AETC AFIT/ENV <joshua.chambers_mills@us.af.mil>;

Cc:Prigge, Diedrich V Civ USAF AETC AFIT/ENV <Diedrich.Prigge@afit.edu>;

BLUF: You have been identified as a potential Air Force Civil Engineering Officer Skills SME. Your response to the linked AFIT research questionnaire is requested by Friday, 17 November 2017.

Good Morning/Afternoon,

PURPOSE: You are receiving this email because you have been identified as a potential Subject Matter Expert in the area of Air Force Civil Engineering Officer Skills. I am a CE officer currently enrolled in the Graduate Engineering Management (GEM) program at the Air Force Institute of Technology (AFIT). The focus of this thesis effort is to identify and evaluate the Civil Engineering Officer Skills.

BACKGROUND: Within the 2016 Civil Engineer Flight Plan, lines of effort 1.1 and 1.2 states that the USAF needs to attract retain and recruit resilient talent and develop tailored, lifelong education and training programs. This study is aimed at assessing the needs of the CE Officer to better understand how we can accomplish these goals. To develop this field of knowledge, the research team is performing a "Delphi Study" in which the research attempts to find consensus among SMEs through several rounds of surveys. The first survey is provided in the link below.

SURVEY INFORMATION: Participation is completely voluntary and you may drop out at any time with no adverse effects. The questionnaire has 3 questions, the first asking participants to rate the applicability of certain skills to Civil Engineer Officers, the second asking for experience, and the third allowing comments and feedback. As you are able, please accomplish the attached survey by 17 November 2017. This survey will be conducted using Survey Monkey to ensure all responses are confidential. Please complete the survey at your soonest convenience.

Survey Link: https://www.surveymonkey.com/r/67ZSCSP

Please let me know if you believe that you have received this email in error. Additionally, if you have any questions or concerns, please let me know. Thank you very much for your time and consideration in this research effort.

V/R,

JOSHUA C. CHAMBERS-MILLS, CAPT, USAF
AFIT/ENV Master's Student
joshua.mills@afit.edu<mailto:william.bentley@afit.edu>
Cell: (719) 235-7816

Survey #1 – Email giving extension, reminder

Re: AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills (Response Requested by 17 NOV 17)

Reply all

participants

All,

Because of the mix-up with the survey, I am extending the time to complete the survey until tomorrow, 22 Nov. I would like to get as much participation as possible to hear from each of you. If you have not completed the survey yet, please do so. The average time for completion has been 8 minutes so far, so please take a moment to help me complete this research. Thank you, the link is below:

Survey Link: https://www.surveymonkey.com/r/67ZSCSP

If you have any additonal questions or comments, please let me know.

Cheers,

Capt Chambers-Mills

_____
From: Mills, Joshua C 1st Lt USAF AETC AFIT/ENV
Sent: Thursday, November 16, 2017 2:49:10 PM
To: CHAMBERS MILLS, JOSHUA C Capt USAF AETC AFIT/ENV
Cc: Prigge, Diedrich V Civ USAF AETC AFIT/ENV
Subject: Re: AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills (Response Requested by 17 NOV 17)

All, please be advised that there was a problem with the original link. I have updated the link below. Please take a few minutes to complete the survey by COB tomorrow. I do not expect it to take more than 20 min in all. And if you have any questions, please let me know.

New link: https://www.surveymonkey.com/r/67ZSCSP

Thank you so much for your time in this,

Capt Chambers-Mills

AFIT/ENV

Survey #2 – Email requesting responses

AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills, Survey 2 and Feedback from Survey 1

Mills, Joshua C 1st Lt USAF AETC AFIT/ENV <Joshua.Mills@afit.edu>

Thu 12/7/2017 3:22 PM

To:CHAMBERS MILLS, JOSHUA C Capt USAF AETC AFIT/ENV <joshua.chambers_mills@us.af.mil>;

Cc:Prigge, Diedrich V Civ USAF AETC AFIT/ENV <Diedrich.Prigge@afit.edu>;

BLUF: You are part of a survey to identify and evaluate Air Force Civil Engineering Officer Skills . All responses have been analyzed and put in order of highest average rating below. Your response to the second AFIT research questionnaire is requested by Friday, 15 December 2017.

Good Morning/Afternoon,

PURPOSE: The research is based on use of a Delphi Study, which uses questionnaires and feedback to determine a consensus result. The survey responses were analysed to determine the average response score on a scale of 1 (Extremely Unlikely) to 7 (Extremely Likely). This represents how the group responded. The second survey is linked below.

SURVEY INFORMATION: Participation is completely voluntary and you may drop out at any time with no adverse effects. The questionnaire has 2 questions, the first asking participants to rate the applicability of categories to Civil Engineer Officers, the second allowing comments and feedback. As you are able, please accomplish the attached survey by 15 November 2017. This survey will be conducted using Survey Monkey to ensure all responses are confidential. Please complete the survey at your soonest convenience.

Survey Link: https://www.surveymonkey.com/r/NFRPSDG

SURVEY #1 DATA:

Rank	Skill	1-Extremely Unlikely	2-Very Unlikely	3-Unlikely	4-Neutral	5-Likely	6-Very Likely	7-Extremely Likely	Total	Average Response
1	Create oral presentations	0%	0%	0%	0%	0%	0%	100%	9	7
2	Leadership and management	0%	0%	0%	0%	0%	0%	100%	9	7
3	Project management	0%	0%	0%	0%	11%	0%	89%	9	6.7778
4	Apply skills as member of multidisciplinary team	0%	0%	0%	0%	11%	11%	78%	9	6.6667
5	Create written presentations	0%	0%	0%	0%	22%	0%	78%	9	6.5556
6	Project cost estimating	0%	0%	0%	0%	0%	44%	56%	9	6.5556
7	Analyze construction documents for planning and management of construction processes	0%	0%	0%	0%	11%	22%	67%	9	6.5556
8	Understand construction quality assurance and control.	0%	0%	0%	0%	22%	11%	67%	9	6.4445
9	Construction project control processes	0%	0%	0%	0%	33%	11%	56%	9	6.2223
10	Project scheduling	0%	0%	0%	0%	11%	56%	33%	9	6.2222
11	Analyze and interpret data	0%	0%	0%	0%	22%	33%	44%	9	6.2216
12	Analyze issues pertaining to ethics	0%	0%	11%	0%	11%	33%	44%	9	5.9994
13	Analyze methods, materials, and equipment used to construct projects.	0%	0%	0%	0%	33%	44%	22%	9	5.8883
14	Risk management	0%	11%	0%	0%	11%	56%	22%	9	5.6667
15	Engage in life-long learning, professional licensure	0%	0%	11%	0%	22%	56%	11%	9	5.5556
16	Accounting and cost control	0%	11%	0%	0%	33%	56%	0%	9	5.2223
17	Plumbing systems	0%	0%	0%	11%	78%	0%	11%	9	5.1111
18	Project safety planning	0%	0%	0%	44%	11%	33%	11%	9	5.1106
19	Electrical systems	0%	0%	11%	22%	33%	22%	11%	9	4.9995
20	Technology	0%	0%	11%	33%	22%	22%	11%	9	4.8884
21	Public policy	0%	11%	11%	0%	44%	33%	0%	9	4.7773
22	Mechanical systems	0%	0%	22%	11%	44%	11%	11%	9	4.7773
23	Business	0%	11%	11%	11%	44%	11%	11%	9	4.6662
24	Transportation engineering	0%	11%	11%	0%	67%	11%	0%	9	4.5556
25	Design engineering	0%	11%	11%	33%	11%	22%	11%	9	4.5551
26	Environmental and water resources engineering	0%	0%	11%	44%	33%	11%	0%	9	4.444
27	Structural engineering	0%	11%	0%	33%	56%	0%	0%	9	4.3334
28	Geotechnical engineering	0%	22%	11%	33%	33%	0%	0%	9	3.7774
29	Hydraulics and hydrology engineering	0%	22%	44%	11%	22%	0%	0%	9	3.333
30	Surveying	0%	50%	25%	13%	13%	0%	0%	8	2.875
31	Design and conduct experiments	33%	22%	33%	0%	11%	0%	0%	9	2.3331
32	Understanding of Calculus Based Physics	56%	22%	22%	0%	0%	0%	0%	9	1.6666
33	Understanding of Differential Equations	67%	22%	11%	0%	0%	0%	0%	9	1.4444
34	Articulating ill-defined problems,					11%			1	5
35	Course-of-Action (COA) Analysis for					11%			1	5

Survey #2 – Email reminder

2/8/2018 Re: AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills, Survey 2 and Feedback from Survey 1

Re: AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills, Survey 2 and Feedback from Survey 1

Reply all |

participants

All,

Please take a few minutes to take the next survey before Friday, 15 Dec. This survey will hopefully take about 5 minutes and will continue to help in the research effort. Please let me know if you have any questions or comments, thank you.

Capt Josh Chambers-Mills

Survey #2 – Feedback and Notice of Survey Completion

2/8/2018 Re: AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills, Survey 2 and Feedback from Survey 1

Re: AFIT Research: Identification and Evaluation of Civil Engineering Officer Skills, Survey 2 and Feedback from Survey 1

Reply all

participants

Action Items

All,
After analyzing the responses to both surveys, the research team has determined that a consensus has been reached. This consensus is based on the weighted average responses from survey #1 question #1 and survey #2 question #1. Below is a table showing the compared weighted averages for the categories scored in the second category, compared to the ratings from the first survey.

	Survey #1		Survey #2	
Category	Rank	Weighted Average	Rank	Weighted Average
Officership	1	6.1	1	6.86
Project Management	2	5.93	3	6.43
Construction Management	3	5.36	2	6.57
General Management	4	4.49	5	4.86
Technical Understanding	5	4.48	4	5.71
Engineering Design	6	3.51	6	4.29

I am moving forward with the completion of my thesis, which includes additional information and analysis pertaining to the data received from this study. If you would like a copy of thesis, please let me know. After final edits, I would be happy to disseminate it.

If you have any final comments or questions, please let me know.

Again, I can't thank you all enough for participating,
Cheers,
Capt Josh Chambers-Mills
AFIT/ENV

Appendix D Complete Responses to Survey #1

Do you have any other comments, questions, or concerns?
Open-Ended Response

Thanks for the opportunity to complete the survey - good luck with the data analysis and your eventual thesis defense! Happy Thanksgiving, Col

I considered time in a CES as PRIME BEEF since the home-station training is geared towards that specific mission set when engineers transition to contingency operations

1. After 20+ years within CE, I've noticed several trends for young 32E Officers. Each has a strong desire to gain "Design Engineering" experience immediately after college. While our career field (in my opinion) focuses on the project management and leadership aspect of being a CE Officer, gaining strong technical skills at an early age will benefit 32E's later. We need a stronger engineering (Technical) development program for 32E's. My recommendation for the first 6-8 years of the 32E career path is to get as much field experience and technical knowledge as possible. Here's my analogy "If the Lt/Capt doesn't understand how long or what it takes to install an HVAC unit or electrical transformer, how can he effectively plan/program/estimate for that project later as a FGO?" That FGO will not have the "Hands-On" experience so to speak, to be effective at leading squadron processes later. To a large degree, we have become too "Analytics based" in Operational analysis that we've lost the core trade skills of being an Engineer. Not implying that metrics are non-important, but to make my point on this, we developed a flight called "Requirements & Optimization" within CEO. This sounds like a PhD dissertation when the primary function is Maintenance Engineering. R&O is meant for the manufacturing world.....not day-to-day CE ops (I know---I worked as a civilian consulting engineer in private industry). We in CE are viewing operations from a purely academic paradigm....Why you ask? Going back to my initial statement, our Officers are not gaining the core trade type engineering skills (From field experience), so what they know and default to is a purely academic approach (Our comfort zone). From a career development point of view...My honest opinion is we reward 32E Officers more for working on Staff than we do for gaining technical and field knowledge. We are breeding bureaucrats and general knowledge project managers more than seasoned Engineering Officers. Why is this reality important.....When the 32E career field reaches a point where engineering skillsets are lacking, DoD from a macroscopic financial view doesn't need to keep us (They can contract out our job because we are lack the education/experience--this is already happening...i.e...Kirtland AFB, Maxwell AFB, TInker AFB, etc.....). Sincerely believe we are working towards a model of operations similar to the Army (DPW) and Navy (NAVFAC), where base ops are run entirely by federal employees. Without question, we have become more technically deficient due to loss of technical education (Just look at the courses offered by AFIT 20 years ago versus today???) and field experience as 32E Officers during my career timeframe. V/r Lt Col, Commander

The most important skill not discussed above is initiative. I need Officers with initiative who can think for themselves to take on any problem sent their way and achieve mission success. I do not want officers or civilians who continually ask for permission or force a leader to do their job for the subordinate member. This is the biggest thing I look for in Officers and believe it is why we are often tasked with the toughest problems.

On a scale from 1 (Extremely Unlikely) to 7 (Extremely Likely), please rate how likely each skill is to be needed by a Lieutenant or junior Captain in the 32EXX career field. By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Understanding of Differential Equations	Understanding of Calculus Based Physics	Design and conduct experiments	Analyze and interpret data	Engage in life-long learning, professional licensure	Analyze methods, materials, and equipment used to construct projects.	Understand construction quality assurance and control.	Analyze issues pertaining to ethics	Create oral presentations	Create written presentations	Apply skills as member of multidisciplinary team	Technology
1-Extremely Unlikely	1-Extremely Unlikely	3-Unlikely	7-Extremely Likely	6-Very Likely	5-Likely	5-Likely	6-Very Likely	7-Extremely Likely	5-Likely	7-Extremely Likely	4-Neutral
1-Extremely Unlikely	3-Unlikely	2-Very Unlikely	5-Likely	6-Very Likely	6-Very Likely	7-Extremely Likely	5-Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	6-Very Likely
2-Very Unlikely	2-Very Unlikely	5-Likely	6-Very Likely	6-Very Likely	6-Very Likely	5-Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	6-Very Likely	5-Likely
1-Extremely Unlikely	1-Extremely Unlikely	2-Very Unlikely	6-Very Likely	5-Likely	6-Very Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	5-Likely	4-Neutral
3-Unlikely	3-Unlikely	3-Unlikely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	4-Neutral
2-Very Unlikely	1-Extremely Unlikely	1-Extremely Unlikely	5-Likely	6-Very Likely	5-Likely	7-Extremely Likely	3-Unlikely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	6-Very Likely
1-Extremely Unlikely	1-Extremely Unlikely	3-Unlikely	7-Extremely Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	5-Likely	7-Extremely Likely	7-Extremely Likely
1-Extremely Unlikely	2-Very Unlikely	1-Extremely Unlikely	7-Extremely Likely	3-Unlikely	5-Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	3-Unlikely
1-Extremely Unlikely	1-Extremely Unlikely	1-Extremely Unlikely	6-Very Likely	5-Likely	6-Very Likely	7-Extremely Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	5-Likely

Design engineering	Project safety planning	Project cost estimating	Project scheduling	Analyze construction documents for planning and management of construction processes	Risk management	Accounting and cost control	Construction project control processes	Project management	Business	Public policy	Leadership and management
4-Neutral	4-Neutral	6-Very Likely	6-Very Likely	5-Likely	6-Very Likely	2-Very Unlikely	5-Likely	7-Extremely Likely	4-Neutral	5-Likely	7-Extremely Likely
6-Very Likely	5-Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	5-Likely	5-Likely	6-Very Likely	7-Extremely Likely	5-Likely	3-Unlikely	7-Extremely Likely
2-Very Unlikely	4-Neutral	6-Very Likely	5-Likely	6-Very Likely	7-Extremely Likely	6-Very Likely	5-Likely	5-Likely	6-Very Likely	5-Likely	7-Extremely Likely
4-Neutral	4-Neutral	7-Extremely Likely	6-Very Likely	6-Very Likely	6-Very Likely	5-Likely	5-Likely	7-Extremely Likely	3-Unlikely	5-Likely	7-Extremely Likely
7-Extremely Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	6-Very Likely	5-Likely	7-Extremely Likely	7-Extremely Likely	5-Likely	6-Very Likely	7-Extremely Likely
6-Very Likely	4-Neutral	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	2-Very Unlikely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	5-Likely	2-Very Unlikely	7-Extremely Likely
5-Likely	6-Very Likely	7-Extremely Likely	6-Very Likely	7-Extremely Likely	6-Very Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	5-Likely	7-Extremely Likely
4-Neutral	6-Very Likely	7-Extremely Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	2-Very Unlikely	6-Very Likely	7-Extremely Likely
3-Unlikely	7-Extremely Likely	6-Very Likely	6-Very Likely	7-Extremely Likely	6-Very Likely	6-Very Likely	7-Extremely Likely	7-Extremely Likely	5-Likely	6-Very Likely	7-Extremely Likely

Structural engineering	Environmental and water resources engineering	Transportation engineering	Geotechnical engineering	Hydraulics and hydrology engineering	Surveying	Mechanical systems	Electrical systems	Plumbing systems	Other (please specify up to 5 skills with rating)
4-Neutral	3-Unlikely	3-Unlikely	2-Very Unlikely	3-Unlikely	2-Very Unlikely	3-Unlikely	5-Likely	4-Neutral	Articulating ill-defined problems, Course-of-Action (COA) Analysis for leadership to make decisions,
5-Likely	4-Neutral	5-Likely	5-Likely	3-Unlikely	4-Neutral	4-Neutral	5-Likely	5-Likely	
4-Neutral	4-Neutral	5-Likely	4-Neutral	2-Very Unlikely	2-Very Unlikely	5-Likely	4-Neutral	5-Likely	
4-Neutral	4-Neutral	2-Very Unlikely	3-Unlikely	3-Unlikely	2-Very Unlikely	5-Likely	5-Likely	5-Likely	Joint Engineering Planning & Operations - 5
5-Likely	5-Likely	5-Likely	4-Neutral	5-Likely		5-Likely	6-Very Likely	5-Likely	
5-Likely	4-Neutral	5-Likely	5-Likely	5-Likely	5-Likely	7-Extremely Likely	7-Extremely Likely	7-Extremely Likely	Contracts & Contracting skills (Very Likely), Project programming (Very likely), Long range base planning (Very likely), CE/DoD Financial Systems (If not covered in the "Business" question) (Extremely likely).
5-Likely	5-Likely	5-Likely	5-Likely	3-Unlikely	3-Unlikely	6-Very Likely	6-Very Likely	5-Likely	
2-Very Unlikely	6-Very Likely	6-Very Likely	2-Very Unlikely	2-Very Unlikely	3-Unlikely	5-Likely	3-Unlikely	5-Likely	
5-Likely	5-Likely	5-Likely	4-Neutral	4-Neutral	2-Very Unlikely	3-Unlikely	4-Neutral	5-Likely	

PRIME BEEF	REDHORSE	Staff	Explosive Ordinance Disposal	Readiness and Emergency Management	OCONUS Tours (including deployments)	Joint	Other (please specify)
3-5 Years	0 Years	6+ Years	0 Years	1-2 Years	3-5 Years	0 Years	
1-2 Years	3-5 Years	0 Years	0 Years	1-2 Years	3-5 Years	0 Years	
3-5 Years	1-2 Years	0 Years	0 Years	0 Years	1-2 Years	0 Years	AFIT GEM
6+ Years	0 Years	3-5 Years	0 Years	1-2 Years	6+ Years	1-2 Years	
6+ Years	3-5 Years	3-5 Years	0 Years	3-5 Years	6+ Years	0 Years	Engineering Educator (Instructor at AFIT CE schoolhouse for 3 years)
3-5 Years	0 Years	3-5 Years	0 Years	1-2 Years	3-5 Years	3-5 Years	
6+ Years	0 Years	3-5 Years	0 Years	1-2 Years	3-5 Years	0 Years	
6+ Years	0 Years	1-2 Years	0 Years	0 Years	1-2 Years	0 Years	Engineering Education - 6 years

Appendix E Complete Responses to Survey #2

#1

COMPLETE

Collector:	Web Link 1 (Web Link)
Started:	Thursday, December 07, 2017 4:34:25 PM
Last Modified:	Thursday, December 07, 2017 4:36:08 PM
Time Spent:	00:01:43
IP Address:	140.32.16.3

Page 1

Q1 After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	**7-Extremely Likely**
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	**6-Very Likely**
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	**7-Extremely Likely**
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	**4-Neutral**
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	**5-Likely**
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	**6-Very Likely**

Q2 Do you have any other comments, questions, or concerns? — **Respondent skipped this question**

#2

COMPLETE

Collector:	Web Link 1 (Web Link)
Started:	Thursday, December 07, 2017 4:56:14 PM
Last Modified:	Thursday, December 07, 2017 5:00:14 PM
Time Spent:	00:03:59
IP Address:	132.3.13.79

Page 1

Q1 After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	**7-Extremely Likely**
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	**5-Likely**
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	**6-Very Likely**
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	**4-Neutral**
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	**6-Very Likely**
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	**7-Extremely Likely**

Q2 Do you have any other comments, questions, or concerns? — **Respondent skipped this question**

#3

COMPLETE

Collector:	Web Link 1 (Web Link)
Started:	Friday, December 08, 2017 8:52:45 PM
Last Modified:	Friday, December 08, 2017 8:54:18 PM
Time Spent:	00:01:32
IP Address:	73.157.119.204

Page 1

Q1 After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	**6-Very Likely**
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	**7-Extremely Likely**
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	**7-Extremely Likely**
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	**7-Extremely Likely**
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	**7-Extremely Likely**
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	**5-Likely**

Q2 Do you have any other comments, questions, or concerns? — **Respondent skipped this question**

#4

COMPLETE

Collector:	Web Link 1 (Web Link)
Started:	Sunday, December 10, 2017 5:48:55 PM
Last Modified:	Sunday, December 10, 2017 5:52:37 PM
Time Spent:	00:03:42
IP Address:	132.3.65.82

Page 1

Q1 After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	**7-Extremely Likely**
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	**7-Extremely Likely**
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	**6-Very Likely**
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	**3-Unlikely**
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	**6-Very Likely**
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	**3-Unlikely**

Q2 Do you have any other comments, questions, or concerns?

no additional comments to add.

#5

COMPLETE

Collector:	Web Link 1 (Web Link)
Started:	Wednesday, December 13, 2017 12:06:17 PM
Last Modified:	Wednesday, December 13, 2017 12:17:03 PM
Time Spent:	00:10:45
IP Address:	132.58.234.20

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Q1 After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	**7-Extremely Likely**
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	**7-Extremely Likely**
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	**7-Extremely Likely**
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	**5-Likely**
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	**5-Likely**
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	**5-Likely**

Q2 Do you have any other comments, questions, or concerns? — **Respondent skipped this question**

#6

COMPLETE

Collector:	Web Link 1 (Web Link)
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Q1 After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	**7-Extremely Likely**
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	**7-Extremely Likely**
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	**7-Extremely Likely**
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	**5-Likely**
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	**6-Very Likely**
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	**5-Likely**

Q2 Do you have any other comments, questions, or concerns? — **Respondent skipped this question**

#7

COMPLETE

Collector:	Web Link 1 (Web Link)
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Q1 After reviewing the results from Survey #1 for each skill, please rate how likely each category is needed for a Lieutenant or junior Captain in the 32EXX career field. After each category is a list of example skills that fall within it (not exhaustive). Use the same scale as previous, from 1 (Extremely Unlikely) to 7 (Extremely Likely). By likely, we mean how often would a skill be used or how important is that skill for a CE Officer to execute their duties. The more you feel the skill is needed, the higher you would rate it. The less you feel the skill is needed, the lower you would rate it.

Officership (Leadership, Oral and Written Communication, Teamwork, etc.)	**7-Extremely Likely**
Construction Management (Construction Documents and Methods, Quality Assurance, Project Control, MEP Systems, etc.)	**7-Extremely Likely**
Project Management (Cost Estimating, Scheduling, Risk Management, Safety, Contracting, etc.)	**5-Likely**
Engineering Design (Structural, Transportation, Geotechnical, Environmental, etc.)	**2-Very Unlikely**
Technical Understanding (Analyze and Interpret Data, Technology, etc.)	**5-Likely**
General Management (Accounting/Cost Control, Public Policy, Business, Financial Systems, etc.)	**3-Unlikely**

Q2 Do you have any other comments, questions, or concerns? — **Respondent skipped this question**

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

The USAF Engineer (CE) officer career field involves a host of duties and opportunities for technical competence and leadership excellence as the Air Force mission grows and personnel numbers shrink. Most CE officers spend their careers as a technical manager, performing a mixture of duties that require a wide variety of skills. Because of this, the use of engineering design skills have decreased and the use of project and construction management have increased. While the career field accepts a variety of architecture and engineering degrees for new accessions, technical management degrees like Construction Management have been denied. This study uses a Delphi study to rate a list of skills most needed by CE Company Grade Officers, and compares those skills with the accreditation outcomes for Civil Engineering and Construction Management undergraduate degrees. After 2 rounds of surveys, a list of 40 skills was used to compare the relative emphasis of the degrees. Construction Management was shown to emphasize higher rated skills. Civil Engineering still showed a high relation to the skills, but emphasized engineering design skills that were consistently rated lower by the Delphi panel. The research shows that accredited Construction Management display a better fit for CE officers and should not only be considered acceptable, but encouraged for new accessions.

15. SUBJECT TERMS
Delphi, Civil Engineer, Construction Management, Accreditation, Education

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