Practical Concepts for

# Capstone Design Engineering

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# Preface

Training the next generation of engineers and engineering educators is a national priority, but with declining enrollment in undergraduate engineering programs and declining interest in engineering education, the resulting critical shortage of qualified workers has intensified the need to strengthen the professional competency of the graduates entering the engineering workforce despite a robust demand in the workplace. In the long term, the growth and development of human civilization will rely on the ability to resolve challenges using science, technology, engineering, math, and creativity. The changing materials and environments, along with the infrastructure challenges, are just the surface of the expansive need for competent engineering graduates.

Proposals to enhance engineering design education have included the development of design expectations across the curriculum, team-based learning activities, and assessments to gauge student attainment of outcomes, but the key obstacle for undergraduate students is transitioning from traditional lecture-based coursework to more realistic, practice-oriented training. The key is to stimulate creativity and critical thinking to solve real-world problems by putting engineering skills into practice in the classroom. It is precisely these two components that are missing from the traditional engineering curriculum, which emphasizes the regurgitation of equations and repetition of standard problem sets, neither of which reflects the real world. The capstone design experience during the undergraduate student's senior year provides an excellent opportunity to transition more smoothly from the classroom setting to the workplace environment. Professional engineering is a process, one that first requires a full understanding of the problem and associated challenges (due diligence) and a means to define the problem in a context that can lead to the second aspect—the actual design of the solution.

There is widespread agreement on the value of offering a capstone design course that involves real-world projects, industry partnerships, and student teamwork, but often the stumbling block is time (on the part of both faculty and students) and the need to find or create real-world projects. Help from nonacademics is critical to the success of such a capstone course sequence. To enrich the learning experience of fundamental coursework in the undergraduate program, this textbook was created to provide a framework of the critical components and provide a guide for students and faculty as they navigate through the design process. This book results from over 10 years of teaching the capstone course, integration of experiences from engineering consultants and clients about the expectations of engineering graduates, and comments resulting from the adoption of the basic tenets of the class at several other universities.

Although the capstone design course is found in almost all accredited chemical, civil, environmental, industrial, and mechanical engineering programs, there are no existing textbooks that present the breadth of topics covered here. This text is designed to be adopted for a one- or two-semester sequence in engineering design. For example, at Florida Atlantic University and the University of Miami, the civil engineering capstone sequence is offered as a two-semester course. The capstone courses typically represent the first time that engineering students are exposed to professional practice in their academic program. A two-semester course permits adequate time for the transition from repetitive problem solving to thinking through situations where many of the variables are uncertain or unknown.

However, relying solely on industry to lead the project is unrealistic due to the time commitments for reading and evaluating reports, meeting with students, mentoring, scaffolding progress, and assessing presentations. It is not uncommon to dedicate 20 hours per week or more to a class like this, far more than adjunct professors or industry professionals can devote. Commitment of full-time faculty with the experience and/or willingness to include external concepts is critical to a successful student learning experience. The key is finding the faculty members who are interested in the process, have the experience, and are willing to dedicate the time. Senior design never should be a class that is a burden for someone to teach. The value to students will diminish as a result. Having registered professional engineers involved as a part of the class is extremely valuable to the learning experience and for future employment opportunities.

This textbook will be most meaningful if the student has completed fundamental civil engineering coursework. For prerequisites, students should obtain department approval, and it is recommended that students complete the following coursework prior to enrolling in the capstone course: introductory transportation engineering, soil mechanics, applied hydraulics or fluid mechanics, materials science, structural analysis, surveying, computer-aided design, and introductory environmental engineering. For the second portion of the course, students should have completed the following coursework: steel and/or concrete structures, foundation design, transportation engineering design, environmental engineering design, and hydrology or drainage design. Because the students create their own design solution, they should take the course in consecutive semesters, with the same project and teammates to encourage the students to engage in the project results more fully. Changing groups or adding a student from a prior course often disrupts group dynamics and the design process of the group. This should be avoided. Students should complete the two semesters consecutively, in the same groups.

We should note that in the years since this (required) capstone design sequence was initially offered at the previously mentioned institutions, the course has been consistently rated as the one of the best student experiences in exit interviews, the course that students learn the most in, and the most time-consuming class they took during their academic careers. There is a correlation there. The students get interested in certain aspects of the engineering design process and then aggressively pursue them. The key is to spark interest in students, provide general guidance from faculty and professionals, and allow students to learn and pursue ideas and complex solutions on their own. The results can be inspirational, and student knowledge increases exponentially from the junior year. From the authors' experiences, several projects that were undertaken as part of this course were actually constructed, including a LEED® Gold-certified library (Figure 1), the world's first LEED Gold-certified nanofiltration water treatment plant (Figure 2), a LEED Platinum engineering building

Figure 1 City of Dania Beach, FL LEED Gold library


Figure 2 City of Dania Beach, FL LEED Gold nanofiltration water treatment plant

at Florida Atlantic University, a LEED Gold environmental center, and several public school buildings, in addition to proposed city parks, mixed-use facilities, hotels, and transit stations.

For students whose academic goal is to become a civil engineer, the capstone design course should be the most exciting and valuable learning experience before entering into professional practice. Because there is not a comprehensive textbook that can address the holistic design issues, this textbook was designed to be different from traditional textbooks that cover only the fundamentals of engineering. Instead, it centers on key skills needed to complete a capstone project. The intent is to permit students to transition from purely academic work to solving actual problems in a more realistic setting. The student projects should be real and, whenever possible, developed by working professionals who interact with students and participate as mentors or jury members during the course. This approach of integrating students, faculty, design professionals, clients, consultants, and regulators is the best way we have found to bridge the gap between the classroom and the profession, and the results are always astounding.

# About the Authors

**Frederick Bloetscher, Ph.D., P.E., LEED-AP, DWRE,** is currently an associate professor at Florida Atlantic University in Boca Raton, where his focus is on water resources, water supply sustainability, stormwater (including sea level rise), and wastewater disposal issues. He received his bachelor's degree in civil engineering from the University of Cincinnati and earned his master of public administration degree from the University of North Carolina at Chapel Hill. His Ph.D. is in civil engineering from the University of Miami. His areas of interest include water and wastewater resource management, membrane processes, utility management and finance, groundwater, and waste disposal options. He is also the president of Public Utility Management and Planning Services, Inc. (PUMPS). PUMPS is a consulting firm dedicated to the evaluation of utility systems, needs assessments, condition assessments, strategic planning, capital improvement planning, grant and loan acquisition, interlocal agreement recommendations, bond document preparation, consultant coordination, permitting, and implementation of capital improvement construction. Dr. Bloetscher was previously an adjunct faculty member at the University of Miami in Coral Gables, the former utility director and deputy director for several large water and sewer systems, and a former city manager in North Carolina. He is the former Chair for the Water Resource Division Trustees, Groundwater Resource Committee and Education Committee for the American Water Works Association. He is a LEED-AP and holds professional engineering licenses in nine states.

Dr. Bloetscher has been nominated for the Teacher of the Year award a number of times by his students and has received two university-wide leadership awards, plus two national leadership awards. Dr. Bloetscher co-teaches the first semester of the capstone design course at Florida Atlantic University and leads the second, where the planning and conceptual design of green building construction is turned into preliminary plans, specifications, and basis of design reports.

In 2012, Dr. Bloetscher and Dr. Meeroff received the National Council of Examiners for Engineering and Surveying (NCEES) Award for Connecting Professional Practice and Education for their work on the Dania Beach nanofiltration facility, which is the first LEED Gold water treatment facility in the world. Dr. Bloetscher was the LEED administrator for the project.

**Daniel E. Meeroff, Ph.D., E.I.,** is associate chair and professor in the Department of Civil, Environmental & Geomatics Engineering at Florida Atlantic University (FAU). His area of specialization is environmental engineering, more specifically, water and wastewater engineering, water chemistry, solid/hazardous waste management, sustainable building strategies, and pollution prevention. Dr. Meeroff is the founder and director of the Laboratories for Engineered Environmental Solutions (Lab.EES) at FAU (http:\\labees.civil.fau.edu). He earned his bachelor's degree in environmental science from Florida Tech and his master's and Ph.D. degrees in civil/environmental engineering from the University of Miami. In 2011, Dr. Meeroff was selected by the students for the Excellence and Innovation in Undergraduate Teaching Award at FAU and has been nominated for the Teacher of the Year award numerous times by his students. In 2014, the Engineer's Council recognized Dr. Meeroff as the John J. Guarrera Engineering Educator of the Year, and the student body at FAU selected him as the Distinguished Teacher of the Year, the highest teaching honor at the university. In the field of green building design, Dr. Meeroff co-teaches the first semester of the innovative capstone design course at FAU.

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Downloads available for *Practical Concepts for Capstone Design Engineering* include instructor material such as final exams, course syllabi, grading rubrics, and PowerPoint® slide shows that correspond with specific topics within the book. All materials can be modified for classroom instruction.

# 1

# Introduction to Capstone Design

As noted in the preface, training the next generation of engineers and engineering educators is a national priority (National Academy of Sciences 2005). Declining interest in engineering education and the consistent erosion of the number of required credits for a degree have created a critical shortage of qualified professionals, yet the complexity of societal issues has intensified the need to increase and expand the professional competency of the engineering workforce for the next generation (Seymour 2001). Students need to learn more, but have less time to do so, and currently much of that time is devoted to rote problem solving as opposed to actual engineering. The key obstacle for undergraduate students is transitioning from traditional lecture-based coursework to more realistic, practice-oriented training. As a result, there is widespread agreement on the value of offering a capstone design course that involves real-world projects (Padmanabhan and Katti 2002), industry partnerships (Kumar 2000), and student teamwork in preparation for entering the engineering workforce (Todd et al. 1995).

The Accreditation Board for Engineering and Technology (ABET) calls for accredited undergraduate engineering degree programs to have a capstone design experience in which fourth-year students work in teams for one or two semesters on a practical design project. The purpose of a capstone course is to provide students with a culminating engineering design experience that allows them to apply the fundamental coursework and skills learned during their engineering curriculum to solve an engineering problem in a way that incorporates appropriate engineering standards with multiple realistic constraints. Capstone projects should be industry-related, which helps to bridge the gap from the university environment to the professional ranks.

Engineering infrastructure projects typically are designed to last for long periods of time, and their life cycle impacts on the environment are not fully explored during typical undergraduate coursework. By integrating concepts such as teamwork, mentoring, life cycle analysis, and environmental stewardship into the preliminary design phase, engineering graduates will be better prepared to actively play a role in improving the condition of both the built environment and the natural environment, putting them in position to make lasting contributions to building a sustainable future. One way to accomplish this is by introducing the concept of high-performance building design and green engineering into the capstone course.

The goal of a capstone design course, or sequence, must be to encourage students to use their creativity, innovation, curiosity, and educational foundations to solve complex, real-world problems. To enrich the learning experience of fundamental coursework in the undergraduate program, it is necessary to expose students to practical applications of the basic subdisciplines of the engineering curriculum, including elements of the key courses they have taken prior to their senior year. In addition, classes that students typically will take as seniors, such as engineering economics, construction management, and other technical electives, will be important.

## 1.1 The Capstone Design Process

For students whose academic goal is to become a professional engineer, the capstone design course should be the most exciting and valuable learning experience before entering into practice. According to ABET, many subjects make up the engineering disciplines, and students need an understanding of all of those subjects to be successful in their careers and to obtain their professional licenses. The focus of this book is different from traditional textbooks in that this one is designed to integrate many aspects of the professional practice experience, instead of just covering the fundamentals of engineering. The capstone course and the resulting project center around skills that involve the successful design development of a real-world project such as a commercial/institutional high-performance building, with ancillary issues such as environmental impacts, transportation, resiliency against natural disasters, flood protection, compliance with local ordinances, application and interpretation of building codes, and concepts that limit options such as economics, local politics, and even historical preservation. These multiple realistic design constraints are similar to those that professionals have to address every day in their careers. The project should be real or based on a real project. It may actually be in the design process when assigned, and, whenever possible, the design professionals working on the project should be a part of the course in some meaningful way.

In the first phase of the capstone project, students perform a project needs assessment, conduct site reconnaissance, and develop a conceptual design that often includes floor plans and site plans. In the second phase, the project is taken from the conceptual stage to a set of preliminary design drawings. A professional engineer should be engaged to approve acceptable conceptual plans, which serve as the basis for developing a set of preliminary design drawings (using AutoCAD® and Revit® or other three-dimensional building information modeling software), along with all of the design calculations, modeling results, and support documents that comprise a basis of design report. Throughout the course, student teams will present their progress to an invited jury of outside professionals (e.g., department advisory council members, practicing engineers, regulators, owners, and other interested stakeholders) to provide feedback and comments whenever possible. This interaction with working professionals is critical for the growth of student engineers into practice. The intent is to transition students from purely academic work to solving actual problems in a more realistic setting.

## 1.2 Course Objectives

Students are expected to learn how to approach complex challenges, discover solutions, and deal with multiple realistic design constraints while incorporating engineering design standards. It is important to realize that there is no solution manual for capstone projects. While often there are many different answers that will work in the real world, designs are considered elegant, clever, and innovative instead of partially correct. The idea is to expose students to the thought process of how an engineer arrives at an appropriate solution. Creativity, ingenuity, and innovation are important and always must be encouraged. Professionals will find that students have great ideas and often challenge the status quo, which is a good thing for the profession and society.

Participants in the course are expected to communicate effectively in a professional manner, both in written and presentation format. The following is an example of the stated objectives in a capstone course syllabus:

- Develop design project teams and deliverables acceptable to a sponsor or client
- Develop effective communication, teaming, and leadership skills
- Develop an understanding of professional practice issues, such as involvement in professional societies, licensing, ethics, and continuing education
- Develop a practical understanding of the application of engineering economics
- Integrate prior engineering coursework to develop feasible solutions while incorporating appropriate engineering standards with multiple realistic constraints (see Figure 1.1)

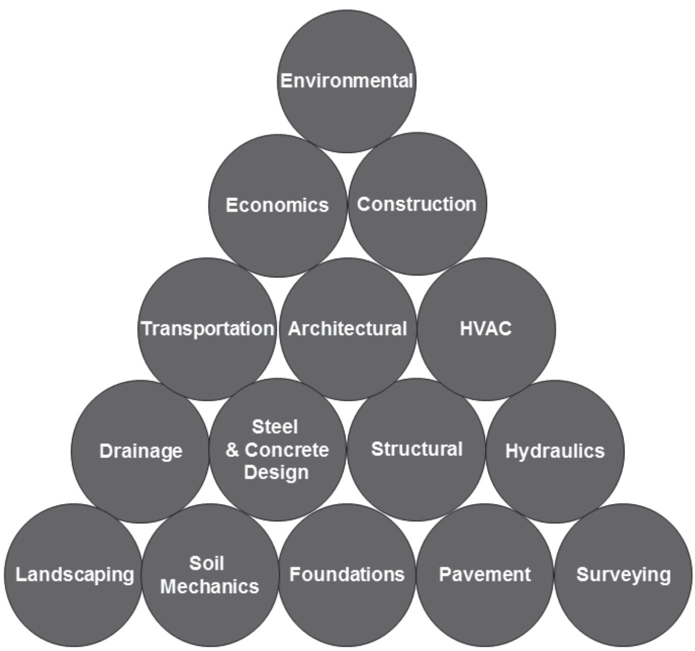


**Figure 1.1 Integrated design approach that utilizes all prior coursework for design of a high-performance building project**

## 1.3 Project Selection

A suitable design project will incorporate as many of the aspects of the engineering curriculum as possible. The local zoning board, community redevelopment board, members of the department industry council, and even alumni are great sources for capstone projects. Locally significant construction projects may be easier to coordinate compared to theoretical exercises or projects that are located great distances away. Local governments often start planning years in advance for projects, which makes them perfect for students to work on. Students should physically visit potential development sites to learn how to gather data in the field. This is *not* a satellite image activity done by computer. Students need to experience the sites with their own senses. Realization that the work will be evaluated by professionals in the field or the actual owner of the project adds to the richness of the learning experience.

It is important to make sure that the capstone project is not too focused on one single aspect of engineering, such as site development or highway design, which may alienate students interested in other engineering disciplines. For example, design of a multistory building encompasses nearly all of the elements of engineering training, with the possible exception of certain aspects of environmental engineering. That is why it is important to place an emphasis on high-performance building design by requiring students to meet sustainability criteria such as the LEED® checklist from the U.S. Green Building Council® or other systems such as BREEAM, CEEQUAL, PERSI, and Green Globes, among many others. Examples of suitable projects that have been successfully pursued by students of the authors include college dormitories, hospital buildings, libraries, water and wastewater treatment plants, digester gas energy capture projects, school buildings, mixed-use buildings, hotels, train stations, local multimodal transportation projects, office buildings, apartments, airport terminals, recreation centers, civic buildings, and parks.

When developing a capstone project for this course, each student team should be provided with (1) a scope of work that outlines the client's needs, (2) key technical information such as a geotechnical report near the job site with results of a soil boring log and soil bearing capacity tests, and (3) a contact person at the job site (from either the ownership group, the construction management team, or the architect's office) to assist in coordinating site visits, interviews, and information requests.

## 1.4 Course Management Structure

A capstone design course works best when it is team taught by faculty members (representing the fundamental academic engineering perspective), consulting engineers (representing the practical engineering perspective), and government officials (representing the owner's perspective or the regulatory perspective), along with contributions from a variety of outside lecturers to provide both academic and real-world connections. It is vital that at least one (and preferably as many as possible) of the members of the instructional team is a licensed professional engineer. By focusing on project-based learning through the development of a high-performance building for example, students also will learn how to practice responsible stewardship. Thus, students will be better prepared to deal with an evolving job market in an ever-changing world with an increasing human population, energy and water limitations, adaptations to climate change, and economic and social inequities.

The role of the instructional team is to act as the principal engineers in charge of the students' fictional consulting firms. They also serve a guidance function by providing the project background, interpreting scope issues, acting as an initial facilitator or liaison between the student groups and the client, providing critical reviews and feedback, assigning change orders, and enforcing class policies and procedures. The instructors also have the final say in conflict resolution.

## 1.5 Group Selection

Prior to becoming eligible for the capstone design course, students typically must obtain department approval. It is recommended that the following prerequisites be completed *prior to* enrolling in the course:

1. Introductory transportation engineering
2. Soil mechanics
3. Applied hydraulics or fluid mechanics
4. Materials science
5. Structural analysis
6. Surveying
7. Computer-aided drafting
8. Introductory environmental engineering

In other words, students should be eligible to register for the Fundamentals of Engineering (FE) exam within 6 months of registering for the class.

For the second portion of the course, it is strongly recommended that the following coursework be completed before starting:

1. Steel and/or concrete structures
2. Foundation design
3. Transportation engineering design
4. Environmental engineering design
5. Water resources, hydrology, or drainage design

By the first class meeting, each student should submit a resume and brief personal statement that identifies his or her engineering interests, past and current employment, career goals, perceived strengths and weaknesses, and geographic information. This last piece of information is critical because the class may be made up of widely diverse commuter students or the course may be delivered through a long-distance learning platform; hence, appropriate arrangements can be made to facilitate effective student teams.

Several lessons have been observed through the process of team selection. Groups should not be assigned randomly, nor should students be allowed to select their own groups. Using the information provided in the resume and personal statement, teams of three to five students each are assigned based on several key pieces of information, including ability to communicate effectively, leadership abilities, and grade point average (GPA). It is important to have students with different interests in each group. For instance, if all four members of a team are interested in transportation, then who will do the structures or the surveying? It also is important to consider group dynamics. For instance, a team of four members with weak leadership personalities will tend to struggle to get work done. Finally, GPA should be considered as well. If a high-GPA student is paired with low-GPA students, only one student may want to do all the work, and the other three will not get as much value out of the experience.

Once the groups are established, a project manager is selected by the team members. The duties of the project manager are to oversee and coordinate team activities, create and maintain a collegial atmosphere, ensure professional-quality work is submitted on time, build team consensus, resolve conflicts within the team, delegate and assign tasks to individual team members and micro-teams, approve time sheets, and maintain the group's focus on the project goals. It is not uncommon for the individual who serves as project manager to change over the course of the project, depending on team needs or personal issues. The other team members' roles are to attend group meetings, show initiative, take responsibility, contribute thoughtfully, give and receive useful feedback, deliver on commitments, avoid friction between team members, assist teammates by checking each other's work, and do *more* than their fair share of the effort.

## 1.6 Course Delivery Structure

The course employs two overlapping teaching methodologies: lecture and professional practice sessions. The lectures focus on introducing certain aspects of the engineering profession that will be relevant to the assignments. The first several weeks of the course include critical lectures to convey the appropriate background concepts and lay the framework and expectations for the rest of the class. These topics include the following:

- **Technical communication skills**—A premium is placed on professional-quality writing, outlining, effective graphical presentations, persuasive writing, creativity, and logical thinking. The focus here is to be able to present engineering concepts and ideas to different audiences using computer-based tools and other visual aids, in both written and oral formats. Separate modules are presented for preparing engineering progress reports, responses to requests for proposal, technical memos, and construction documents.
- **Project management skills**—Strategies for working effectively in a team setting and developing leadership skills, project management tools, and scheduling capabilities are addressed.
- **Alternative analysis skills**—Methods to systematically analyze engineering alternatives to come up with the preferred option using objective criteria are presented.
- **Site assessment skills**—Guidelines for conducting a Phase I Environmental Site Assessment based on the most recent version of ASTM 1527 are covered.
- **Site planning skills**—Concepts involving zoning, easements, setbacks, rights-of-way, parking requirements, landscaping issues, accessibility, and drainage, as well as water, sanitary sewer, stormwater, reclaimed water, cable TV, natural gas, telephone, electrical, and wireless utilities are presented. This topic also should include a brief discussion of conceptual development of programming for the overall site layout and floor plans.
- **Engineering economics skills**—The time value of money, preparation of preliminary cost estimates, quantity takeoffs, and bidding are discussed.
- **Ethical conduct**—The concepts of engineering ethics and the professional responsibilities of professional engineers are presented.

In the beginning of the second phase of the course, a series of technical lectures are presented which focus on specific design considerations and approaches, such as structural building concepts; foundation concepts; plumbing concepts; roadway design; drainage strategies; lift station design; heating, ventilation, and air conditioning (HVAC) design; and roof concepts. These brief presentations often are delivered by technical advisors in their specific area of expertise. This serves to introduce the teams to an appropriate design approach for their projects, and it also introduces the technical advisors or outside faculty members to the student teams for later consultation during the semester as mentors.

Beyond the lectures are a series of professional practice sessions that involve presentations of progress toward developing the capstone design; results of investigations; research and data collection; and development of technical memos that describe the basis of design in detail. These professional practice sessions allow the instruction team to foster development of specific engineering skills through guided exploration and to periodically monitor progress. The presentation format can facilitate this growth and help the students make progress throughout each semester toward attaining predefined goals. Each presentation is essentially a milestone in a cleverly scaffolded approach that forces students to make manageable progress toward the final deliverable. The approach is gradual progress toward a basis of design document by dividing up the work into manageable components so that the project grows from the initial design charrettes to a professional-quality report complete with calculations, drawing sets, specifications, and details. Staged presentation times can reduce the tendency of students to go into "crisis mode" to complete the work. Trying to prepare complex calculations and presentations for a client at the last minute does not work in the real world. The goal is to alter student work habits. A jury of faculty, representatives from industry, the client, and peers evaluates the presentations and written reports and provides feedback for revision (see Figure 1.2). Although the students are not yet professionals, they should become accustomed to filling out time sheets for compensation and learn how to manage their time wisely. Instead of money, students are "paid" in grades.


**Figure 1.2 Students sharing presentation with faculty**

## 1.7 Getting Started

Once the project scope has been assigned, each team must come up with a set of well-defined goals and a plan to accomplish them. This plan typically addresses accountability, leadership structure, communication among members, strategies to encourage innovation and sharing of ideas, means to manage and resolve conflicts, and well-defined roles and responsibilities of each individual team member. This begins the process of developing an organizational chart in preparation for responding to a request for qualifications. The next step is to come up with a name and logo for the fictitious consulting firm, along with a shared vision statement to guide decision-making priorities.

Soon after the teams have developed their fictitious design firms, they must begin their initial work by exploring the concept of sustainability and high-performance building design. Teams are encouraged to seek out design inspirations and innovative technologies that they might want to include in their designs at this point. The goal is to establish some key components that will set a team's design apart from competitors. This will be the first opportunity to present in front of the instructional staff and peers. Buoyed by critical evaluations from their first presentation, each student team performs a needs assessment for the project, develops a well-defined scope of work, performs site reconnaissance and engineering due diligence, and then develops floor plans and site plans to create a basis of design report. Then students should have their conceptual plans evaluated by a professional engineer, and each team should prepare a set of preliminary design drawings (in AutoCAD) with all the calculations, modeling results, and support documents for structural, geotechnical, water, sewer, stormwater, and transportation aspects of the project in the second phase of the class.

## 1.8 Deliverables

By the end of the first phase, each team is required to submit its basis of design notebook, along with a complete set of preliminary plans. Preparation of all interim deliverables should have this final work goal in mind. During this first phase, the following deliverables are presented as pieces of the *Final Predesign Notebook*:

1. **General introduction**—Details the team's interpretation of the project scope, design goals, and objectives.
2. **Response to request for qualifications**—Answers the question "Why should you hire our team?" and requires the students to brainstorm ideas and concepts that they plan to incorporate in their proposed design. It also requires the team members to outline their strengths, detail their project management plan, come up with a realistic schedule for accomplishing the work, and refine their professional resumes.
3. **Phase I Environmental Site Assessment**—Answers the question "What are the existing recognized environmental conditions on the site?" and requires the students to investigate the existing site to identify any current or historical recognized environmental conditions, past activities, impacts of development, long-term sustainability, and due diligence. During this exploration, each team conducts site reconnaissance, interviews, and record reviews with federal, state, and local regulatory agencies.

4. **Preliminary site plan**—Answers the question "What is proposed to be built on the site and inside the building?" and focuses each team on developing a preliminary site plan and floor plan for the project. Once again, the scope of work is restated in relation to the design goals, site constraints, and opportunities for innovation. Using this framework, the existing site conditions are presented and a set of viable alternatives are analyzed. The proposed site plan is then presented, along with solutions for stormwater, drainage, parking, accessibility, and utilities, as well as preliminary cost estimates and "green" features. Final floor plans also are presented for approval.

During the second phase, each team should submit a series of progress reports, culminating in the *Preliminary Design Briefing Report*, which includes technical design memoranda for each of the following topics:

1. **Structural plan**—Includes justification for the structural layout, detailed calculations for critical loads, locations of structural elements, and details for all connections, as well as appropriate drawings and specifications.
2. **Foundation plan**—Includes justification for the foundation layout, analysis of the soil borings, a geotechnical report, and a grading plan, as well as appropriate drawings, specifications, and detailed calculations.
3. **Transportation plan**—Includes a breakdown of parking requirements, modeling traffic impacts, appropriate horizontal/vertical curves, pavement design, and cross sections. This plan also addresses access and egress issues, along with Americans with Disabilities Act compliance, and includes appropriate drawings and specifications.
4. **Drainage plan**—Includes justification for the drainage layout including plans to retain all stormwater on-site, for example. Calculations for runoff routing, retention, storage, and treatment, as well as appropriate drawings and specifications, also are included.
5. **Plumbing and HVAC plan**—Includes an analysis of the fixture units, meter sizing, and sizing of pipelines within the building using EPANET or similar simulation software, along with appropriate drawings and specifications. It also includes a concept for design of the HVAC system, with capacity of air handlers, cooling/heating units, control systems, and ductwork.
6. **Roof plan**—Includes evaluation of alternatives to remove stormwater from the roof of the building in a timely fashion, particularly if vegetated roofs (or "green roofs") are utilized. Students use the appropriate building code and their knowledge of applied hydraulics to design slopes, scuppers, overdrains, downspouts, and roof sealing materials to prevent roof leaks. Appropriate drawings and specifications also are included.
7. **Utilities plan**—Includes a capacity analysis for sizing potable water, sanitary sewer, reclaimed water, stormwater pipelines, and irrigation. Design drawings include plan and profile views.
8. **Landscaping plan**—Many local governments have landscaping ordinances. In many cases, these policies may restrict regional water usage and encourage xeriscaping concepts, drought-tolerant species, local flora, etc. Therefore, students are required to create a landscaping plan that is in compliance with all local and regional regulations.

9. **Energy model**—For long-term operation and sustainability of the building, students must run an energy model to determine what options they may be able to build into the structure to reduce energy consumption.
10. **High-performance building checklist**—Includes an analysis of the potential "green" features captured by the design team, as well as the required documentation.
11. **Preliminary cost analysis**—Outlines the capital costs for delivering the building project, including equipment, materials, labor, installation, design development, and contingencies.

## 1.9 Assessment

Homework assignments that cover the various lecture topics are collected approximately biweekly. Homework subjects include technical communication skills, resume writing, interpretation of codes, and analysis of engineering alternatives. A final examination is given on lecture materials, largely focused on engineering economics, technical communication skills, alternative analysis, and site planning. In this exam, students are encouraged to use the *FE Reference Handbook* and FE-approved calculator. Another component of the final grade is a subjective score assigned to level of professionalism, as exhibited by the quality of in-class discussion and interviews with instructional staff outside of class. Before grades are assigned at the end of each phase, it is recommended that involvement in at least one professional society function, event, conference, or competition be required. The purpose is to encourage students to develop networking opportunities with practicing professionals outside of the educational setting (and get jobs). Also, the reputation of the institution within the local community is enhanced when students participate in civic engagement activities with their future peers.

Interpersonal relationships with teammates are an important component of the group dynamics; therefore, students submit time sheets for approval signatures (from the project manager and one of the principals) on a biweekly basis. At the end of each phase, students are asked to reflect on the performance and contributions of their team members as well as submit a self-evaluation, as part of the *Final Predesign Notebook*.

By design, the largest portion of the grade should be allocated to the professional practice assignments. These are comprised of (1) timed 20-minute oral presentations with 10 to 15 minutes for answering questions and feedback and (2) written reports, each of which is assigned equal weight. Group members generally receive the same score on presentations and on submittals, except in very unusual circumstances (e.g., a team member does not participate). The oral presentations allow the student groups to experience what it is like for consultants to report to their clients. Minimum requirements for the content of each deliverable are explicitly spelled out in the syllabus. Student teams make final presentations to a jury consisting of members of the department advisory committee, faculty, invited professionals, alumni, and interested stakeholders. This final presentation is treated like a milestone event in the career of the engineering student. For many, it will be the final act before graduation. The popularity of the final presentation with local industry representatives is a testament to their understanding the importance of participating in the education of their future employees.

The jury for the final presentation scores the technical content, knowledge of the subject matter, effectiveness of visuals, organization of the presentation, coordination and participation of team members, professionalism, and responses to questions on a scale of 1 to 5. A sample grading sheet is shown in Table 1.1, which divides the evaluation into the following sections: content, organization, delivery, discussion, and overall impression. The ability of students to field questions during and after the presentation also is scored. A rubric is quite helpful in letting the students know the level of expectation for each of the presentations. A sample rubric is shown in Table 1.2.

Because students are "paid" in grades, the assignments should consist of evaluations based on the professional quality of the team-based interim professional practice assignments (pre-

**Table 1.1 Example of a grading sheet used to evaluate student presentations**

| Please indicate a score based on a scale of 1 to 5 where:<br>5 = Excellent 4 = Good 3 = Fair 2 = Weak 1 = Poor | | | | |
|---|---|---|---|---|
| | Team 1 Name | Team 2 Name | Team 3 Name | Team 4 Name |
| **CONTENT** | | | | |
| **Subject matter**<br>(technical content) | | | | |
| **Knowledge of subject**<br>(understanding of issues demonstrated) | | | | |
| **ORGANIZATION** | | | | |
| **Introduction**<br>(objectives clearly presented) | | | | |
| **Continuity**<br>(facts presented in a logical sequence, transitions well) | | | | |
| **Conclusion**<br>(reasonable summary and recommendation presented) | | | | |
| **DELIVERY** | | | | |
| **Schedule**<br>(effective use of time, well prepared, rehearsed) | | | | |
| **Body language**<br>(eye contact, no distracting or annoying mannerisms) | | | | |
| **Visuals**<br>(clear, free of clutter, effective, related to discussion items) | | | | |
| **DISCUSSION** | | | | |
| **Question and answer**<br>(answers reflect understanding of topic) | | | | |
| **OVERALL IMPRESSION** | | | | |

**Table 1.2 Example of a rubric for student presentations**

| | Excellent | Good | Fair | Poor | Unacceptable |
|---|---|---|---|---|---|
| ☑ **Content** | All team members display professional level of knowledge of subject matter, with no important content left out and no incorrect material presented. | All team members display professional level of knowledge of subject matter, with minor amount of subject material left out or minor amount of incorrect material presented. | Majority of team members display professional level of knowledge of subject matter, with minor amount of subject material left out or minor amount of incorrect material presented. | Some team members display professional level of knowledge of subject matter, with minor amount of subject material left out or minor amount of incorrect material presented. | No team members display professional level of knowledge of subject matter, with minor amount of subject material left out or minor amount of incorrect material presented. |
| ◆ **Subject matter** | All important topics are covered during the presentation, with no essential elements missing or misrepresented. | | | | |
| ◆ **Knowledge of subject** | Each member of the team demonstrates an understanding of the essential topics presented. | | | | |
| ☑ **Organization** | Presentation has a strong introduction, an effective body of material that supports the conclusion, and a strong ending. | Presentation has deficiencies in only one of the following: introduction, body, or conclusion. | Presentation has deficiencies in two of the following: introduction, body, or conclusion. | Presentation has deficiencies in all of the following: introduction, body, and conclusion. | Presentation is missing introduction, body, or conclusion. |
| ◆ **Introduction** | Presentation starts strong with scope and objectives clearly presented. | | | | |
| ◆ **Continuity** | Facts are presented in a logical sequence and presentation transitions effectively between speakers. | | | | |
| ◆ **Conclusion** | Finishes strong with reasonable summary and/or recommendations presented, as justified from the body of the presentation. | | | | |
| ☑ **Delivery** | Presentation is effective in terms of rhythm, visuals, and presenters' body language. | Presentation has deficiencies in only one of the following: rhythm, visuals, or presenters' body language. | Presentation has deficiencies in two of the following: rhythm, visuals, or presenters' body language. | Presentation has deficiencies in all of the following: rhythm, visuals, and presenters' body language. | Presentation is clearly not rehearsed, visuals are unprofessional, and/or presenters' body language is unprofessional. |

| | Excellent | Good | Fair | Poor | Unacceptable |
|---|---|---|---|---|---|
| ◆ **Rhythm** | Presentation demonstrates effective use of time, presenters seem well prepared, and presentation appears rehearsed. | | | | |
| ◆ **Visuals** | Visuals are effective, free of clutter, related to the discussion, and meaningful. | | | | |
| ◆ **Body language** | Presenters maintain eye contact with the audience and are free of any distracting or annoying mannerisms. | | | | |
| ☑ **Discussion** | All questions are fielded professionally, confidently, and correctly while avoiding defensive or argumentative responses. | Majority of questions are fielded professionally, confidently, and correctly while avoiding defensive or argumentative responses. | Some questions are fielded professionally, confidently, and correctly while avoiding defensive or argumentative responses. | Only one question is fielded professionally, confidently, and correctly while avoiding defensive or argumentative responses. | None of the questions are fielded professionally, confidently, and correctly while avoiding defensive or argumentative responses |
| ◆ **Question and answer session** | Answers supplied reflect an understanding of the topic. | | | | . |
| ☑ **Overall impression** | Presentation addresses all important subject matter, demonstrates conceptual understanding of the content, and responds to the purpose of the report; slides are cohesive, clear, concise, and organized well; presentation has many strengths; delivery is professional; question and answer session shows excellent engineering judgment. | Presentation addresses most of the important subject matter, demonstrates conceptual understanding of the content, and responds to the purpose of the report; majority of the slides are cohesive, clear, concise, and organized well; presentation has strengths; delivery is professional; question and answer session shows good engineering judgment. | Presentation addresses some of the important subject matter, demonstrates conceptual understanding of the content, and responds to the purpose of the report; some of the slides are cohesive, clear, concise, and organized well; presentation has few strengths; delivery is professional; question and answer session shows some engineering judgment. | Presentation addresses little of the important subject matter, demonstrates conceptual understanding of the content, and responds to the purpose of the report; some of the slides are not cohesive, clear, concise, or organized well; presentation requires major revision; delivery is not professional; question and answer session shows lack of engineering judgment. | Presentation is completely unprofessional. |

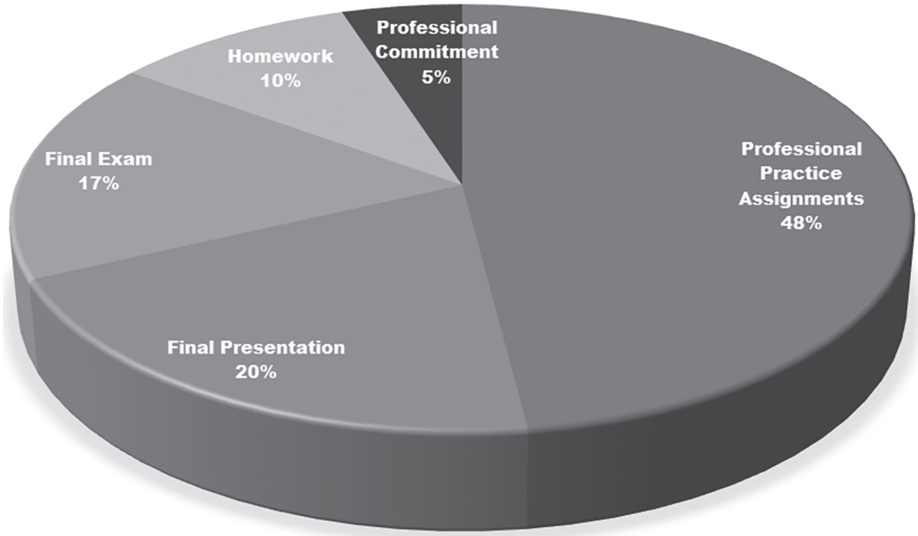


**Figure 1.3 Example of grading breakdown structure**

sentations and reports) and the final presentation and report. Individual performance also is evaluated on exams, homework, and other assignments such as class discussions, critiques, feedback, and attendance at professional meetings (professional commitment). An example of a grading breakdown structure is shown in Figure 1.3.

## 1.10 Last Words

The course content and delivery of a capstone design class are very different from traditional lecture courses in which students are trained to work out problems in the back of the book. Because the capstone class focuses on practice-oriented design, the course functions to tie all of the fundamental concepts together in a realistic project that will better prepare students for the upcoming challenges in their careers. The opportunity to work on a real project that will actually be constructed is valuable exposure to engineering practice. The demands of the course require the students to develop time management skills as they learn to work successfully in a team environment on their own. The open-ended nature of the course allows students to explore creative alternatives, and the participation of industry partners acts to channel that creativity so as to be grounded in practical feasibility and cost competitiveness.

## 1.11 References

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# 2

# Career Opportunities and Leadership

As an engineer, there will be many potential career opportunities in the job market and many opportunities to grow and develop. Engineers are in high demand because there are many types of engineering jobs available from which to choose, such as regulators (state, federal, and local governments), equipment manufacturing representatives, contractors, public works and utility managers (both public and private), engineering consultants, project managers, business owners, and academicians. The current infrastructure crisis and aging nature of the workforce will ensure a favorable job market for entry-level engineers for many years to come. Students should ask themselves if they want to be involved with project management, design, manufacturing and sales, construction, instruction, regulation, or higher education. There are exciting, interesting, and challenging job opportunities in each field.

It is encouraging to note that graduates from engineering programs rarely have much difficulty finding a job related to civil, environmental, construction, or geomatics engineering, especially if their communication skills are excellent. The importance of good communication skills cannot be overstated. Careers depend on them, so they will be discussed more later.

## 2.1 Self-Assessment

Each student needs to decide where his or her interests lie. No one should choose for an individual. Will the career path lead to the private sector or the public sector? If a student wants to have extensive hands-on training, then working for a large private firm or perhaps a government utility, transportation department, public works entity, or regulatory agency may have more appeal. Most large entities offer some degree of mentoring and oversight to allow an entry-level employee to grow into a professional engineer under the guidance of a more experienced engineering supervisor.

In contrast, a student who craves independence may be attracted to a small to medium-size private firm or agency. Keep in mind that engineers need a license to practice engineering (or to even call themselves engineers in some jurisdictions), so before starting a business, it is important to gain experience. Without the professional engineering license, starting a business will be extremely difficult. The downside to joining a smaller company is that there is less opportunity to receive mentoring, but the excitement of working on many different types of projects tends to keep boredom from repetitive work at a minimum.

Because engineers generally have many opportunities to advance and increase their salaries, especially after obtaining their professional engineering license, students should not focus too much on starting salary when first joining the workforce. Keep in mind when getting that first job that the starting salary should not be the only criterion. It is vastly more important to enjoy the job and the tasks being performed so that the job does not feel like work. A job should be more than that—it should be interesting and challenging, with varied types of roles and responsibilities. There also are other considerations in any evaluation of a prospective job: working hours, travel requirements, retirement programs, lifestyle, training opportunities, and opportunities for personal growth and career advancement.

It may be helpful to do some soul searching and ask some important questions. Remember to be honest here:

- What do I want to do first?
- What do I want during the next 3 to 5 years?
- Where do I want to be in 10 years?
- Where do I want to be in 30 years?

Develop a plan and implement it. For example, in the third year of engineering school, students should be pursuing internship opportunities, should be holding leadership positions in a professional society, should be performing well academically in the junior-level coursework (this is the core engineering curriculum), and should be identifying and refining personalized engineering interests and career goals. By the fourth year, students should be updating their resumes, actively conducting a job search and attending career fairs, interviewing, networking with practicing engineers through professional societies, attending professional meetings regularly, contemplating graduate school, and preparing for (and passing) the Fundamentals of Engineering exam.

Young engineering graduates are well positioned to be successful, but there are important concepts to keep in mind during the transition from a supportive academic world to the harsh reality of the professional world, where difficult business decisions are made often. Bill Gates, former CEO of Microsoft Corporation, has established a series of rules about life for potential graduates in America, which apply to engineering graduates as well (Sykes 1995):

Rule 1: Life is not fair—get used to it!
Rule 2: The world doesn't care about your self-esteem. The world will expect you to accomplish something BEFORE you feel good about yourself.
Rule 3: You will NOT be a vice-president until you earn it.
Rule 4: If you think your teacher is tough, wait until you get a boss.

Rule 5: No job is beneath your dignity. Your grandparents had a different word for burger flipping and house cleaning—they called it opportunity.

Rule 6: If you mess up, it's not your parents' fault, so don't whine about your mistakes; learn from them.

Rule 7: Before you were born, your parents weren't as boring as they are now. They got that way paying your bills, cleaning your room, and listening to you tell them how idealistic you are. So before you save the rain forest from the blood-sucking parasites of your parents' generation, try delousing the closet in your own room.

Rule 8: Your school may have done away with winners and losers, but life HAS NOT.

Rule 9: Life is not divided into semesters. You don't get summers off, and very few employers are interested in helping you FIND YOURSELF. Do that on your own time.

Rule 10: Television is NOT real life. In real life, people actually have to leave the coffee shop and go to real jobs.

Rule 11: Be nice to nerds. Chances are you'll end up working for one someday.

## 2.2 Types of Job Opportunities

In the public sector, opportunities exist at various levels of government, such as:

- Federal government (e.g., Environmental Protection Agency, Department of Energy, Corps of Engineers, Federal Highway Administration, etc.)
- State government (e.g., departments of environmental protection, water management districts, departments of transportation, etc.)
- Local governments including cities, counties, and special districts (e.g., water and sewer departments, public works divisions, utility authorities, permitting offices, growth management, etc.)
- Others (e.g., universities, NGOs)

Public sector jobs usually have greater job security and more stable salaries, but this does not mean that the compensation is necessarily lower than in the private sector. Public sector positions traditionally have had strong retirement programs, long hours (which limit flexibility), and more repetitive or mundane types of work (offering less challenging projects for young engineers), although the opposite can also be true—lots of challenging opportunities. Often, public sector employers are looking for people who want to "step up" or get ahead quickly. Young engineers can help advance their careers quickly under such conditions. However, some public sector jobs have a graduation grade point average (GPA) requirement of 3.0. If a graduate's GPA is lower than this, then job opportunities may be restricted.

In the private sector, opportunities exist in many different types of companies, such as:

- Developers
- Consulting firms
- Contractors

- Manufacturing and sales
- Vendors
- Private utility companies (e.g., telephone, power, cable, water, and sewer)
- Privately held not-for-profits and NGOs if not public
- Research and development (e.g., pharmaceutical companies, petroleum/mining companies)

Private sector jobs generally have different advancement potential and greater earning potential in those companies that are successful in garnering work. The downside will be the number of hours, which can vary widely depending on the amount of work, and less job security, which is more dependent on the economy rather than performance and merit.

Key items of interest when sorting out potential employment opportunities include:

- **Organization**—Is the organizational structure conducive to future success and vertical advancement?
- **Profession**—Does the job description align with personal career goals and interests? If not, the chance of success diminishes.
- **Geographical location**—How willing is a job candidate to move from his or her current location? Is the candidate willing to work in a particular region or climate zone? What about lifestyle? This choice may put an artificial limit on potential job opportunities. For instance, it may be necessary to take a lower paying job in order to stay in a preferred geographic location or to get better hands-on training.
- **Personal guidance**—An engineer needs to have someone in his or her early career, preferably a professional engineer, who can act as a mentor on the path to licensure. It also is helpful to have an employer that is open to training opportunities to expand a young engineer's knowledge of the field.
- **Growth**—Getting good guidance will help an engineer develop professionally—especially to get his or her license. Things like involvement in professional societies can expand opportunities. Some firms will even pay for graduate studies. This is a very good opportunity to enhance future career marketability.

Now that the ground rules are known, it is time to start creating and marketing a personal brand to provide the best odds for success in the profession.

## 2.3 Branding

A student who wants to be successful needs to acquire experience. This means networking and having a resume that stands out, having excellent communication skills, and making a good first impression. This is known as primacy (which will be discussed in Chapter 5). The resume is the first critical piece of branding. Often this document is the first opportunity to make a good impression with a potential employer, as most job applications require a resume and cover letter. The resume should be concise, easy to read, free of errors, and completely honest. For the most part, it contains a summary of the applicant's experience, educational background, any other pertinent qualifications, and contact information. The key to writing an effective resume is being aware that the reader probably will scan it for only a few seconds before making a yes or no decision (Kaplan 2012). Using eye-tracking technology, 30 professional recruiters were sampled over a 10-week period, and it was found that recruiters spend most of the 6 seconds they look at a resume on the applicant's name, educational history, current position, and most recent past position (Evans 2012). The design and layout of the resume, then, should focus on these key elements in the top third of the first page so as not to be overlooked.

The major elements of a resume for engineers are described in more detail as follows:

- **Contact information**—The applicant's name should appear at the top of the page, centered in large type, followed by permanent address, telephone number, and email. Students in college generally have a temporary address as well, so it is important to make sure that any mail sent to the address on the resume will be received. Otherwise, a job offer could go unnoticed. Make sure that the email address does not have an offensive alias. It might be a good time to create a professional email account with your full name. Then make sure to check the account daily so as to respond to any request for an interview in a timely fashion. The telephone number likely will be a personal cellular phone, so make sure that the voice mail message is professional because recruiters will not be amused by a childish message. Another tip is not to take up too much unnecessary space with all of the contact information; just make sure it is at the top and it is correct. Add a link to your online profile, but not Facebook®.
- **Objective**—This optional section describes the career goal of the applicant. It states what kind of job the goal is. The more specific to the field of engineering, the more likely it is the human resources manager will be able to redirect the resume to the appropriate hiring department. This statement, if included, should be targeted specifically to the job description in the advertisement. For example, if the job is for an entry-level traffic safety specialist, then the objective should include the words transportation engineering. Do not make the objective generic or fluffy, like "seeking a challenging, high-paying job with a Fortune 500 company with ample opportunities for advancement."
- **Education**—This section describes postsecondary education in reverse chronological order, that is, the most recent first. Do not include high school here. List all universities or colleges and the degrees earned, or if pending include the expected graduation date. Include other institutions attended beyond high school, even if no degree was obtained. Recent graduates or soon-to-be recent graduates typically will include minors, certificates, relevant coursework, and specific computer programming or software skills. With respect to GPA, listing it on the resume is optional, and it should be included only if good. A 2.3 GPA is a deterrent. Interviewers can simply request the transcripts if they must know the GPA.
- **Licensure**—It is assumed that engineering students and recent graduates will take and pass the Fundamentals of Engineering exam, so make sure to include a section that provides the license number, the state, and the date granted. Then update this section after passing the Principles and Practice of Engineering exam.
- **Skills**—This section should include things such as computer software knowledge, instrument experience, field sampling, surveying, foreign languages, and other relevant skills.
- **Experience**—This section describes the candidate's work experience, listed in reverse chronological order. For each position listed include the dates, the job title, the employer and address, and a brief description of the duties using action words. Do not be afraid to list nonengineering-related work because gaps in the work timeline

are flagged more often than unrelated work. For example, if a previous or current job is in retail, then focus on describing any engineering-related activities, such as leadership roles, bookkeeping, supervision, training, report writing, management, technical equipment operation, productivity optimization, client interactions, volunteer work, other responsibilities, etc. Make sure to describe past job duties in the past tense using action words like "supervised three interns" or "increased productivity by 17% in the first year." When describing current work experience, use the present tense active voice, like "designing an upgrade for a 15-million-gallon-per-day reverse osmosis water treatment plant." Devote some time to crafting this section carefully because it is one of the sections that is critically reviewed by potential employers. Be specific and be concise, while remaining focused on engineering-related skills that will translate to the job in question.

- **Other information**—This optional section is reserved for items like military service, honors, awards, memberships, interests, hobbies, language fluency, etc. It is unlikely that this section will be heavily weighted by prospective recruiters, but it may help to show how well rounded the candidate is or break the ice with the interviewer.
- Do *not* include birth date, marital status, family information, religious denomination, or similar information. There are laws regarding what employers can ask about these issues. Including them in a resume puts employers in a compromised position and indicates the applicant is unaware of basic personnel practices, which can result in disqualification from consideration.

Remember that developing a resume is not a one-time job. It should be updated continuously with every new accomplishment, new skill, and new career milestone. No two resumes will ever be alike, but a sample of an acceptable resume format is shown in Figure 2.1.

In the era of social media, traditional resumes do not differentiate people, except in exceptional cases, so students need to take proactive measures. Dan Schawbel (2009) wrote a book called *Me 2.0*, which outlines how people and companies should create themselves as a "brand" to let others know who they are, what they stand for, and what their beliefs are. The concept is called branding, and the first impression often is the one that sticks with others. As a result, it is important that a personal "brand" be effective.

Employers will find out how much a student cares about the engineering profession by performing Internet searches by name and reviewing comments made on social networks. Anything negative that exists online can and probably will be found by a prospective employer. Consultants, entrepreneurs, and job creators are increasingly using social networking sites like LinkedIn® to find suitable candidates for employment. This is the modern way to find a job and market online. CareerBuilder.com estimates that 53% of hiring managers use social networks as a background check (CareerBuilder.com 2010), so it is absolutely critical to manage personal online content!

Start developing an online profile by registering for popular social media networks; for example, create a Google® account (http://google.com/profiles) or a LinkedIn account. An individual's full name should be used to create a personal account. Nicknames can give the wrong impression or be confusing to potential employers. Fill out all of the sections that relate to the following pieces of information: professional summary, experience, education, recommendations, personal (professional) websites, interests, keywords, and groups. Always include a recent photo (professional quality in formal business attire). Make the profile public, and start a personal network by linking to other social media sites, like Twitter®,

**Tony Flags**

| | |
|---|---|
| **Objective** | |
| **Education** | **University of Miami,** *Coral Gables, FL*<br>B.S. in Civil Engineering, expected May 2016 |
| **Skills** | *Computer*: AutoCAD2014, Revit MEP Suite<br>*Languages*: Fluent in English, Spanish, and Creole<br>*Engineering Skills*: Surveying, laser scanning |
| **Experience** | |
| *2013–2014* | Site Inspector<br>**Hazen and Sawyer, P.C.,** *Boca Raton, FL*<br>◆ Recorded field notes for ASR well installation<br>◆ Prepared accurate engineering reports<br>◆ Served as construction site crew liaison to the firm |
| *2010–2013* | Associate Manager<br>**Sports City,** *Coconut Creek, FL*<br>◆ Served as Acting Store Manager for 6 weeks<br>◆ Interviewed and hired new staff<br>◆ Recognized for exceeding district sales goals by 25% in year 2 |
| **Awards** | ◆ President of ASCE Student Chapter, 2014–2015<br>◆ Tau Beta Pi Engineering Honor Society, 2014<br>◆ National Merit Scholarship, 2012 |
| **Memberships** | ◆ American Society of Civil Engineers, 2013–present<br>◆ Tau Beta Pi, 2013–present |

**Figure 2.1 Sample of an acceptable resume format**

Facebook, etc., to locate personal contacts such as classmates, faculty, coworkers, employers, etc. Create a custom URL using your full name. Update and improve the profile, and take advantage of site tools like “improve your profile” (be sure to follow all directions). Make sure to write a strong personal value statement. Give and receive recommendations. These kinds of firsthand endorsements are highly valued by recruiters.

Conduct an Internet search of yourself to see what online content is associated with your name and review the top 10 results. There are too many horror stories about what is revealed online. For example, one student was surprised to discover that the first item that appeared in an Internet search of his name was a newspaper article about a drug-related crime. Another found out her DUI mug shot and subsequent mug shots for violating her DUI probation were two of the top four photos that show up under images when searching for her full name. Imagine how prospective employers viewed her candidacy after finding those! You might be surprised by what comes up, but note that this is what potential recruiters will be using to form their first impressions. The Internet is forever, but steps can be taken to remove undesirable content.

Branding identifies students by who they are, why they should be considered for a job, or why they might be qualified to do certain kinds of work. Students will use branding in class, their careers, and with professional organizations. It is the entrée into the network of professionals.

## 2.4 Create the Group Design Firm

One challenge students find difficult to cope with is that the future is now. Students need to practice what they should do in the future while in the relatively safe environment of the capstone class. The focus will be on the design team and the expectations for each of its members. Armed with a loosely defined project scope, the first step is for students to introduce themselves to their new teammates and exchange contact information. The next order of business is to select or elect a project manager and then come up with a creative company name that adds meaning to the group. Make it memorable, and try to avoid dull or uninspired names like initials (e.g., J.S.B., Inc. for John, Sally, and Bob), any trademarked names (e.g., Pepsi®, Ace®, etc.), sports franchises, or college mascots.

An example of a clever name is *Catalyst Engineering Consultants*. A catalyst is an instrument of change, and the team wanted to be known to outsiders for their fresh new ideas. A catalyst allows the reactants to come together to speed up the process, indicating that the team works together with the client to get the job done right and on time. Plus, a catalyst is never used up in a reaction, so it is sustainable, signifying that the team considers sustainability concepts as a priority.

Along with a thoughtful concept for the team name, a vision statement will solidify what things are important to the team and how they will impact decision making. Ideally, these core values should connect back to the goals of the project. The statement clearly and concisely conveys the direction of the organization and its priorities. A vision statement is not a slogan. It powerfully communicates the team's intentions and motivates the team toward successful project completion. Some examples include:

> Systematically solving society's situations with safe, sustainable, and superior structures.
>
> We embrace innovative ideas beyond your imagination with safety, efficiency, and the sustainability of our natural environment as our priorities for a better future.

Although these may sound a lot like slogans, they also convey useful information, like what the major priorities of the team are.

## 2.5 Teaming Skills

Acceptance of others and having empathy are the first steps toward coming together, which is the beginning of teamwork. It is important to remember to listen respectfully and carefully to what others have to say. Be aware and be perceptive: there may be something that will be useful to help keep the team working together effectively or solve a team problem. In a team environment, "self-promotion" is counterproductive. The goal is to become more than the sum of the individual parts. Students must suppress any desire to control a situation to gain advantage or personal prestige because eventually this will result in breaking down the team effort and limiting the spontaneity and creativity that can lead the team toward innovative solutions.

Teams that discuss the issues, share opinions, resolve disagreements, and gain an understanding of all the differing points of view offered are teams that function well and perform effectively. Therefore, conditions need to be established whereby every team member has an opportunity to speak and be heard. Some team members may be uncomfortable expressing their opinions, questioning others, or defending points of disagreement in group settings. They likely will distance themselves for fear of confrontation or humiliation. If this happens, one or more important points of view will be silent or lost. It therefore makes sense to create some important ground rules for teamwork:

1. **Speaking**—Only one person speaks at a time. Speak so everyone can hear. Make sure that everyone can hear clearly. Never allow the loudest voice in the group to seize control of the proceedings.
2. **Listening**—Give the speaker full attention. Stay receptive to what others have to say and remain open-minded to new ideas. Listen without making assumptions or judgments. Acceptance of others and having empathy are important prerequisites. Do not engage in side conversations while someone is speaking. Turn off mobile devices. Be aware and be perceptive. Take a moment to understand the argument and comprehend the meaning of the words before reacting.
3. **Using time wisely**—For all team meetings, rehearsals, presentations, and appointments, make a commitment to be on time, start on time, and end on time, as mutually agreed upon. Showing up on time is not enough; be prepared to get the work done in the time allotted.
4. **Focusing**—Stay on target, addressing what needs to be accomplished "in the now" at each team meeting. Use an agenda that states the goal of each meeting at the outset to avoid wasting valuable time. If the discussion goes off course, bring the team back to the goal of the agenda item.
5. **Being open to the outcome**—Keep an open mind about what the outcome of the meeting might be. It could be very different and more refreshing than anticipated.
6. **Honoring personal commitments and trusting in team decisions**—If the team has made a decision, then move forward. There is no sense in continuing to argue a point that has already been decided. If something is not working out, then be flexible enough to admit mistakes and move on from there.
7. **Always making the best effort possible**—It is unethical to do anything else. A team that aims for mediocrity inevitably will miss that goal. Setting the standard too low is a recipe for failure. Set the bar high, and aim to be the best. Show competitive spirit and strive to reach the top. Always play to win!

The best teams are made up of individuals who go out of their way to make each other look good. An effective team has many open lines of communication and meets frequently to discuss progress, plan for future deliverables, evaluate concepts, make decisions, work on deliverables, check each other's work, rehearse presentations, and edit written submittals. Effective team meetings can be very helpful in keeping the project on schedule. However, if team meetings are ineffective, they can be a source of dissention and erosion of team cohesiveness. A good way to keep team meetings successful is to reflect and evaluate how productively the time was spent:

- Did the meeting start and end on time?
- Did everyone participate?
- Were important issues discussed and decisions made?
- Did the team reach a consensus solution?

- Did all team members engage and add to the discussion?
- Did the team allow new ideas to come forward?
- Did the team explore these and include them?
- Was any negative issue brought up?
- Was the team able to resolve the situation?
- Was the meeting efficient and effective?
- Did the team make decisions?
- Did someone record them?
- Did the team stay on the agenda?

No one said it would be easy, and often, just as in real-world situations, conflicts, difficulties, and communication issues arise within teams. This should not come as a surprise. Students need to learn to deal with difficulties in the work environment too. Future success depends on being able to deal with adversity and resolve conflict appropriately. Failure to address issues when they first arise will slowly erode team chemistry, impact the quality of the work, and ultimately affect the students' grades. Welcome to the real world.

Key attributes related to effective high-performing teams include:

- The group has well-defined goals and practices good planning techniques.
- Each team member has well-defined roles and responsibilities.
- The group has decided how to enforce accountability.
- The lines of communication among members remain open at all times.
- Everyone is encouraged to participate and voice their opinion without reprisal.
- The group has established a means to manage and resolve conflict.
- Methods to encourage innovation are in place.
- There is evidence of strong leadership.

Some early team exercises should be undertaken to build team chemistry. For example, teams should answer the following questions:

- What are the team goals?
- What planning is required?
- What are the appropriate roles and responsibilities?
- How will the team deal with leadership and responsibility?
- How will the team resolve or manage conflicts if they occur?
- How will the team maximize communication among members?
- How will the team encourage innovation in the process?

Good team members take responsibility for their assigned roles and duties. They deliver on their commitments with professional-quality work on time. They contribute to team discussions in planning meetings, listen effectively, and ask helpful questions. They should give and receive useful feedback and do *more* than their fair share of the work. Bad individual team members can be difficult to deal with, and they come in many varieties that students need to learn to recognize and deal with in a positive manner. Some examples follow:

- **The know-it-alls**—These people are arrogant and usually have an opinion on every topic, but when proven wrong, they become defensive and aggressive or uncooperative. Students must develop strategies to help them see things from the point of view of others in the group once in a while.

- **The passives**—These people never offer any ideas or let the group know where they stand. They just want to get by with exerting a minimum of effort. Students need to find ways to bring them out of their shells so they can contribute in a meaningful way. Otherwise, they can manipulate the rest of the group indirectly.
- **The dictators**—These people are bullies. They intimidate and dominate the dialogue. They are constantly demanding and brutally critical without empathy. Students must find ways to tone them down while avoiding direct conflict.
- **The "yes" people**—These people agree to any commitment but never follow through. They cannot be trusted to deliver. Students must find ways to get them to come through in a crunch.
- **The "no" people**—These people are quick to point out why something cannot be done. They are dogmatic, inflexible, and negative. Students must find strategies to turn that negativity into productivity.
- **The complainers**—These people prefer to complain about something rather than try to find a solution or provide useful input. Students must find ways to move them into problem-solving mode.

Unfortunately, it is a distinct possibility that everyone will eventually encounter these kinds of character traits, and it is a good bet that most already have come across examples of these types of personalities or recognize them within. These are the people everyone works with, depends on, lives with, and deals with every day.

In addition to the traits of bad team members, there are basically three personality types that seem to hurt group dynamics and group performance the most (Felps et al. 2006). These are known as *bad apples*, because they can spoil the barrel of good apples. Bad apples can manifest themselves as (a) *jerks*, who attack or insult others in the group and take advantage of weak team members; (b) *slackers*, who do less than they are capable of because they are lazy, exhibit poor time management skills, or simply do not care; and (c) *depressive pessimists*, who hate the project, their team members, and everything else in their lives. If a team includes one of these, there is a good chance that person might spoil the group. Figure out how to engage each one productively.

Research shows that groups with bad apples perform 40% worse (Felps et al. 2006), despite the fact that their teammates may be very talented, very smart, or very likeable. On teams with a bad apple, teammates argue and fight and do not share relevant information. In other words, they communicate less. Even worse, team members may take on the bad apple's personality traits. When the bad apple is a jerk, other team members will act like jerks. When the bad apple is a slacker, other teammates will become slackers too, and so forth. Further, team members will not just act this way in response to the bad apple; they will act this way toward each other in a spillover effect, creating a downward spiral toward poor results. Watch out for individual team members who defer to a "natural leader" and keep their opinions to themselves, as well as people getting frustrated and conflicts erupting. Conflict is inevitable in a team process, and that is why teams should establish the guidelines for high-performing groups discussed earlier.

It all starts with personal accountability, and one way to demand accountability is to create a written agreement or contract called a team performance agreement, which includes some or all of the following items:

- Agree on the specific roles of each member.
- Agree on the guidelines for interaction and communication.
- Agree on where the meetings will be held.
- Agree on how disagreements will be handled.
- Agree on how conflict be will resolved.
- Agree on how final decisions will be made.
- Agree on the consequences of failing to meet the conditions of the agreement.

Decorum also is important both within and outside of the group. Decorum is correct or proper behavior that shows respect and good manners. Students are expected to respect one another and act in a professional manner at all times. To this end, it is important to state that it is disrespectful to hold a conversation in the audience while others are presenting. Streaming videos, downloading music, watching podcasts, checking email, texting friends, playing video games, updating profiles, doing homework for other classes, etc. are not conducive to learning. Such behavior is disrespectful and unprofessional and could be grounds for dismissal. There is a good reason to observe the other group presentations, which is to learn how to listen and at the same time to learn what presentation strategies are effective and which strategies do not work so well. Students might gain some insight on solutions and challenges with respect to their own projects merely by listening to the other groups. That is actually the point!

The worst offense is for a team member to hold a conversation while another team member is presenting. This shows a complete lack of respect. It also tells the audience that the speaker is not worth listening to. To those in the audience, it is abundantly clear which teams take the assignment seriously versus those who met just before class to try to pull something together at the last minute. Wasting student, faculty, and visitor time is disrespectful to group members, but more importantly, it is disrespectful to the client and the project itself. Ultimately, those who are not fully invested in the success of the team will negatively impact their personal professional reputation as well as the reputation of the engineering firm. Eventually this will affect one's ability to garner work and retain clients. Individuals who take this route do not last long in the profession. Respect is a goal for engineers—to gain the trust and respect of others. But respect is earned, not given, and it starts with decorum.

All engineering students can be successful in class and in their careers. The capstone class allows students to acclimate to the difference between academia and the profession. Through this process, students will develop an understanding of their responsibilities in the workplace and how their contributions can enhance the project for everyone involved. Success breeds more success for the organization, so start with good habits in class—now!

## 2.6 References

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## 2.7 ASSIGNMENTS

1. Consultants, entrepreneurs, and job creators are using online profiles to find suitable candidates for employment. This is an emerging way to find a job and market yourself online. Create a profile using an online service such as LinkedIn:
   - Use your full name to create your account.
   - Fill out all of the sections so that the profile is 100% complete. This includes key items such as professional summary, experience, education, recommendations, websites, interests, keywords, professional photo, and groups.
   - Start a network by searching through the site to find personal contacts such as classmates, faculty members, coworkers, employers, etc.
   - Write a strong personal value statement.
   - Print out the complete profile or submit a link to your instructor.
2. Conduct an Internet search of your name and submit a screenshot of the top 10 results. Did you find any of the results in the top 10 to be misleading or damaging to your online reputation? Try the same thing with an images search for your name.
3. Complete a Google profile (http://google.com/profiles). Register your Google account and fill out all fields. Add a suitable avatar (professional photo), and make the profile public. Then link it up to all of the online profiles that you have created.
4. Discuss your favorite rule from Bill Gates' rules about life and describe how it can be useful in managing your career goals as an engineer.

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