Pedagogical Changes to a Capstone Course to Foster Refinement of Professional Skills

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Abstract

For both accreditation purposes and for student professional development, ensuring students develop professional skills is an integral part of an effective undergraduate engineering program. Engineering programs throughout the country have developed a variety of methods to hone these professional skills, typically involving a capstone project experience. At our institution, the culminating design course has grown over the past 20 years and has developed into a capstone program that delivers positive outcomes for both our students and stakeholders. A key emphasis of our program is that students show the application of teamwork, leadership, problem-solving, design, project execution and management skills to real-life civil and environmental engineering problems. The capstone experience has morphed over the past 20 years from a single project completed by the entire graduating class in small teams to multiple projects with separate stakeholders for each capstone team. The current structure is a two-course sequence that incorporates several pedagogical approaches to help students apply and hone their professional skills. Standardized or common grading rubrics, guidance, and assessment tools have been developed and used uniformly by all capstone groups under the direction of faculty advisors and a course coordinator. These guidelines include mandatory weekly progress meetings with advisors followed by documented meeting minutes that are disseminated to the project team (including the advisor and the stakeholders); a final comprehensive technical report; a final notebook that demonstrates their progress throughout the semester; and a final presentation where the teams present to all stakeholders of the capstone projects. Assessment data and faculty observations indicate significant improvement of students' leadership, teamwork, and communication skills at completion of the capstone course. The authors discuss the developmental changes implemented in this two-course capstone experience and an assessment of the impact of the pedagogical approaches used to enhance student learning and development.

Introduction

Ensuring students acquire professional skills is an integral part of an effective undergraduate ABET- accredited engineering program. Engineering programs throughout the country have developed a variety of methods to hone these professional skills and a capstone project experience is typical. The structure of these courses has evolved to incorporate changes in pedagogy, technology, needs of industry and changes in ABET accreditation requirements. There are numerous examples in Engineering Education literature of successes in capstone courses including tips and cases studies of programs running effective capstone projects. For example, Yost and Lane [1] reported the evolution of the civil engineering design capstone experience at a research university, discussed measures to assess communication competence, and reported lessons learned while working with industry partners. They developed a capstone course designed to provide a unified effort in developing teamwork skills, multidisciplinary interaction, communication skills, fundamentals of engineering design processes, and application of engineering design principles to a real engineering project. The course provided greater breadth in developing cost estimation skills, procurement of work, bidding versus quality based selection processes including a presentation of qualifications based on the project request for proposals, and how the design professionals, the client and the construction professions interact to construct a project. Kampf et al [2] reported

using practicing engineers and communications experts to provide feedback on the capstone design documents generated by the students at the University of Minnesota, and to assist in designing written assignment handouts that guided students through the project development process. They recognized that the students need to be able to shift from the communication that has helped them succeed in the classroom to writing for complex audiences and making oral presentations in professional settings. Therefore, the role of consultants in the capstone project writing process has shifted from commenting on papers to presenting information focused on guiding students through the writing process and helping students with their presentations. Ruwanpura et al [3] reported the organization of a civil engineering capstone course that embodied a very significant international component and the difficulties inherent to that component. The novel approach adopted for the capstone project was to use the largest urban renewal project in Europe for which students had the opportunity to develop a design. Students had the opportunity to design major elements of the urban renewal scheme as part of the capstone project course. Sixty-three students participated in preparing a design proposal for a full-scale urban renewal development in Lisbon, Portugal. The students had to learn about Lisbon which has different architectural and construction regulations, a different culture and history, and a different business culture. The students gained an opportunity to be immersed in an international, real-world experience that will be invaluable to their development of design analysis and critical thinking. Howe et al [4] reported the comprehensive results of a 2015 capstone design survey as compared with 1994 and 2005 surveys across all engineering disciplines. They found these capstone courses were largely structured with design projects and classes run in parallel over two semesters, and typically covered a wide range of topics often geared toward professional preparations. The top five common topics cited frequently by the 522 respondents at 256 institutions contributed to the 2015 survey were: written communications, planning and scheduling, oral communications, concept generation/selection, and team building/teamwork. Other important topics which were commonly presented in the capstone project courses include: engineering economics, design for X, professional preparation and licensure, and safety/liability. Regarding the "product vs process" debate, the 2015 survey respondents tended toward a balanced approach or a slight emphasis on the process depending on the engineering discipline. The survey showed civil/environmental engineering departments placed more emphasis on the process since most projects are on a scale too large to be produced/completed by students. The 2015 survey also noted that 70% of the capstone projects were sponsored externally and the opportunity for the students to interact professionally with the sponsors of these projects. Furthermore, survey results showed that capstone design instructors provided most of the evaluation of student work, followed by project coaches, and industry liaisons. The capstone final reports, presentations, and product had the largest role in the student work evaluation, but the process and design reviews were also important. Recently Mintz [5] recognized that the students' needs and goals are changing and called on faculty to transform teaching and assessment approaches to the new reality. There has been a shift from relatively homogeneous to highly diverse classrooms and recognize that a one-size-fits-all teaching pedagogy won't work. Therefore, it is essential for faculty to continuously monitor student learning and diagnosing gaps and confusion in engineering courses. Mintz also cited the professional skills employers wanted from college graduates in addition to technical expertise that include:

- critical thinking and problem-solving skills (ability to analyze issues, make decisions, and overcome challenges).
- oral and written communication skills (ability to articulate ideas clearly and persuasively).
- teamwork skills (negotiate, manage conflict, interact with diverse cultures).

- leadership skills (manage and motivate others; organize and delegate work).

Leidig et al [6] reported a case study of emerging community-engaged experiential learning in capstone design courses through the Engineering Projects in Community Service (EPICS) at Purdue University. Community engagement programs have been demonstrated to motivate students to work harder, develop professional skills such as teamwork, communications, self-directed life-long learning, and design skills. EPICS multi-disciplinary projects, vertically integrated teams, partnering with community not-for-profit organizations, involve students from freshman to senior year and not all work is appropriate for capstone. The process of identifying appropriate community projects involves a project proposal developed by the students in consultation with the team's advisors (instructors). These proposals include information on the overall community engagement project, anticipated capstone specific products and deliverables, design and testing approaches, timelines, and plans for demonstrating each of the ABET Student Outcomes. EPICS course standard assessment practices applied to capstone projects include notebook documentation of work and accomplishments, weekly and summative reflections, design review presentations, transition documents, and peer evaluations. The notebook is filled with data on all the project-related activities the students are actively involved in, often with links to specific work artifacts, explanations of them, and concise narratives explaining the student's specific individual contribution to them. The weekly and summative semester reflections ask students to write briefly about their experience and learning through three components: reflective observation, conceptualizing and connecting their observation to a broader concept, and connecting how they will use their experience and learning in the future. The design review presentations are given twice per semester to a group of outside volunteer reviewers, including industry professionals and community partners, with the goal of gathering feedback on how best to proceed with the project work. This reported case study serves as a method to successfully integrate community engaged engineering design projects with capstone experience and meeting ABET Criteria 3 Student Outcomes.

At the U.S. Coast Guard Academy, the culminating design course has grown over the past 20 years and developed into a capstone program that delivers positive outcomes for both our students and our stakeholders. A key graduation requirement of our program is that students complete a capstone project that includes the application of teamwork, problem-solving, design, project execution and professional skills toward a real-life civil and environmental engineering project. The capstone experience has morphed from a single project completed by the entire graduating class in small teams to multiple projects with separate stakeholders for each capstone team. The current structure is a two-course sequence that incorporates several pedagogical approaches to help students apply and hone their professional skills.

Professional Skills

For our capstone course, we define professional skills as the personal and personnel skills that employers want from college graduates. This professional skill set has changed over the past 20 years. To align with the demand signal of employers, the desirable professional skills of our graduates have also changed. Today's engineering community demands technical engineering competence while also valuing professional skills like oral and written communication, teamwork skills (negotiate, manage conflict, interact with diverse cultures) and leadership skills (manage and motivate others, organize and delegate work) [5]. The Engineering Accreditation Commission (ABET) also recognizes this same need and requires civil engineering graduates to demonstrate

competency in these professional skills. These skills are assessed in ABET [7] Criteria 3 Student Outcomes 1-7, specifically:

> 2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
>
> 3. An ability to communicate effectively with a range of audiences.
>
> 4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements.
>
> 5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
>
> 7. An ability to acquire and apply new knowledge as needed using appropriate learning strategies.

Capstone Course Management

In the late 1990s, the School of Engineering at USCGA initiated a comprehensive assessment program to address the new accreditation criteria established by ABET EC2000. This assessment process led to several curricular improvements, enhanced student learning and an educational program that better meets the needs of the Professional Engineering community and the U.S. Coast Guard. As a part of the assessment process, each course is subjected to an End of Course Review (EOCR) process where assessment data focuses on achievement of the various educational outcomes (ABET Criteria 3, for example). All educational outcomes are reviewed and discussed with recommendations for course improvements. In 2000, because of the EOCR process, the Civil Engineering faculty created the framework for today's capstone course based on multiple input such as student end of course surveys, constituent focus groups, senior exit surveys, and faculty observations.

The capstone design course, CE 1402 *Civil Engineering Design (CED)*, was developed to mimic the civil engineering experiences students will face when they enter the engineering workforce after graduation. While this capstone course model continues to evolve and improve with each successive year, assessment data shows that course and program objectives of graduating students who can "plan, design, execute, and manage a complex open-ended civil engineering project" are being met [8]. In accomplishing this goal, students produce engineering design documents, construction drawings, cost estimates, construction schedules, and any other necessary project specific documents. In addition, students conduct a site visit to meet their stakeholders and view the challenges in the field. Students meet weekly with their faculty advisors to communicate their progress. At least once after the site visit, students provide their stakeholder/client with a virtual progress brief presentation. At the culmination of the semester, the student team presents the results of their project via a technical report and a formal presentation to stakeholders and an auditorium full of undergraduate students, some of whom have limited, if any, engineering background.

In 2023, the *CED* course structure was expanded to a two-course sequence; a one-credit preparation period in the Fall followed by a 4-credit course in the Spring. The additional 1-credit was incorporated into our Construction Project Management (CPM) course as part of the capstone experience. Expanding the course into the Fall semester allows the students a specific credit in the Fall devoted to background research, project familiarity including an initial stakeholder meeting, site visit, and more focus on the professional skills – team development, communication, etc. This two-course structure incorporates several pedagogical approaches to help students apply and hone their professional skills.

Course coordination

One of the keys to success for this course structure is the assignment of a course coordinator. At many universities throughout the United States, multiple sections of the same course are not common. These various sections may not be coordinated; meaning each instructor has the freedom to assign tasks and deliverables and run the course how they see fit. This approach can result in uneven distribution of workload and resources as faculty member expertise and course demands could vary. Furthermore, this could cause an inequity of student knowledge, especially for prerequisite courses.

At USCGA, the Civil and Environmental Engineering Program (CEE) identified the benefits of course coordination and we have successfully used this approach in our capstone course for more than 15 years. This approach mimics a design cycle with constant feedback centered around three key activities (planning, execution, and assessment). Apart from the identified benefits, another contributing factor to using a course coordination approach is that a third of our faculty is rotating military personnel (RMF; temporary personnel stationed at USCGA for 2 to 4 years). Course coordination helps maintain a high level of academic consistency and performance as new RMF develop their teaching and mentoring skills. The course coordinator provides stability across the different sections and ensures consistency in planning, execution, and assessment of all of the capstone projects despite the fact that each team is assigned a unique project. The following are examples of activities classified as planning, execution, and assessment:

Planning: Activities prior to the first day of class.

- In preparation for the new semester, the course coordinator commences by reviewing the End Of Course Review (EOCR) and course objectives from the previous offering to identify those new ideas which worked well, and areas for improvement. As a part of the EOCR process, the multiple instructors of this course provide feedback for recommended content changes.
- Develop course schedule including exams and other assignments.

Execution: Activities during the semester.

- Once the semester commences, the course coordinator provides a steady stream of materials and information to instructors and students. These materials cover a wide range, including project assignment, submission deadlines, example problems, and innovative ways to present the material.
- The coordinator posts course content information to online platforms (MS Teams and D2L) to ensure proposed materials are shared among the instructors for peer review and comment, confirming the product is ready for students well in advance.

Assessment: Course coordinator is also responsible for course assessment including selection of assignments for assessment, and the development and implementation of rubrics as appropriate.

- Assessment data are used in the EOCR process. The EOCR captures qualitative and

quantitative data on students' performance and course activities including faculty input from small group discussions and impromptu meetings.

Project Selection Process

Another important responsibility of the course coordinator is to solicit potential capstone projects and develop a list of projects for discussion by the faculty. Over the years, it has become apparent that proper project selection and scoping is essential to achieving the educational outcomes defined for the course while ensuring that the projects are useful to clients. Typically, our capstone projects are real-life civil engineering needs from the United States Coast Guard Civil Engineering field units. Our CEE academic program has a unique partnership with the Coast Guard Civil Engineering Units (CEUs) and Facilities Engineering Divisions of larger Coast Guard units located throughout the United States and Puerto Rico. Sometimes, non-Coast Guard projects are selected, usually community-based efforts. Projects vary in complexity and focus, but they all provide students with exposure to the design, planning, supervision, and management of actual civil engineering projects. They also serve as an avenue for students to hone their professional skills.

The capstone project selection process includes faculty consideration of constituent and student feedback, the ability to locate "real-world" projects that can be successfully completed in the allotted timeframe, and availability of funds. Project criteria such as funds for site visits, mandatory design component, project schedule, realistic stakeholder expectations, and the expertise of faculty advisors weigh heavily in the selection process. Over the summer, a temporary list of projects is generated by the course coordinator and the available projects are grouped by discipline. Effort is made to have at least one project in each civil engineering subfield covered at USCGA-structural engineering, geotechnical engineering, environmental engineering, and construction or multiple combinations of these depending on faculty interest and expertise. Projects with no design components are rejected if such components cannot be added by the course coordinator in consultation with the faculty. Once projects are selected, students are organized in teams and assigned a project based on their interests. Evaluating stakeholders' expectations against this timeline is crucial. Ensuring a reasonable timeline has resulted in some projects being split into subcomponents to ensure timely deliverables.

Pedagogical changes that have fostered the refinement of professional skills

The capstone experience is designed to provide a forum to practice the art of engineering under conditions encountered in engineering practice. The goal of our capstone experience is to establish a learning environment where professional skills can be taught, developed, and honed alongside the expected technical engineering skills. Students enter the capstone experience with a relatively consistent level of technical competency as they have reached their culminating engineering experience. With professional skills, however, their level of comfort and ability to perform these skills can vary greatly.

In every instance possible, the goal of this course is to mimic real-life engineering project planning, design, and execution. There is growing evidence that the needs and goals of students are changing and so should our approach in how we engage them in the learning process. Some of these drivers of change include [5]:

- *Student expectations are shifting*. Students have more of a "do-it-yourself" attitude towards learning. They don't want to sit passively through lectures; a growing number of them want

to engage. The course setting or structure must provide multiple opportunities for this engagement to occur.

- *Students have grown less compliant*. In general, students are more willing to challenge professors' claims, dispute interpretations and call for the inclusion of alternate perspectives. Therefore, instructors must foster and encourage such inquiry to promote more student engagement and learning.
- *The diversity of the student population* – Common frames of reference or a common level of preparation can no longer be expected. One size fits all pedagogies no longer work. Continuously monitoring student learning is essential, and the learning environment must be inclusive of all levels as much as practical.
- *The skills that employers want from college grads are changing*. Employers value the skills of critical thinking, oral and written communication, teamwork skills (negotiate, manage conflict, interact with diverse cultures) and leadership skills (manage and motivate others; organize and delegate work)

At USCGA, we intentionally use several pedagogical approaches to enhance student learning. From the way course material is delivered to assessment activities, focus on pedagogy is consistently considered. The following paragraphs describe some of the pedagogical strategies used in our capstone course:

Research-based Learning: Development of Expertise

This pedagogy involves having students undertake independent research. A key benefit is that it fosters the development of information literacy skills.

In consultation with their faculty advisor, each member of the teams is expected to select a technical topic or aspect of the project for which they will be responsible. They then become the subject matter expert for that aspect of the project. They are expected to conduct the appropriate level of research and document their findings in their project notebook/report. An excerpt from the assignment is shown in Figure 1.

Capstone Research Paper Assignment

Your research paper for CPM should demonstrate that each member of your team is developing the necessary skills to become an independent, life-long learner. The research paper requirements and assessment rubric have been provided. The following requirements apply to your research paper outline to ensure your team is making good progress on your research:

- Draft a project problem statement that the team will use to guide their research and design efforts.
  - How to write a problem statement (https://www.youtube.com/watch?v=ygPeGZSWVHo)
- Draft a purpose / goal statement to help focus your research to support your group's problem statement.
- Identify a minimum of ten (10) appropriate technical references from a variety of sources such as technical books, manuals, reports, journal articles, web sites, etc.
  - Research Tips: Performing a Literature Review (https://www.youtube.com/watch?v=CeJsj1fpOFo)
- Begin summarizing some of your key research points from each of the references you select. ***This summary must include at least two Figures or Tables to demonstrate how you will incorporate these items into the development of your research paper.***
- Include citations in any of the written work you begin to draft and references at the end of the outline. Follow the referencing requirements provided in the course syllabus.

Figure 1. Capstone Research Paper Assignment

Collaborative Learning: Teamwork Skills Development

This pedagogy involves groups of students working together to solve a problem, complete a task, understand a concept, or undertake a project.

This pedagogy has been a key factor in the successful completion of our capstone projects. Students both individually and as a team identify their strengths and build a collaborative community to address the problem at hand. Students work in teams of 3 or 4 to complete all the project assignments. Their first assignment is to develop a team charter and establish metrics to measure the team's progress. Students are given full control of all aspects of their projects, and they set the pace by publishing the timeline in which they plan to complete all tasks. Based on key milestones provided by the course coordinator, the group determines their project due dates and provides their timeline to the course coordinator and their faculty advisors. While students collectively work on their project, each week the team rotates through the role of lead engineer. The lead engineer is responsible for ensuring approaching deadlines are met and that meetings are run professionally. Each student holds this role multiple times throughout the course of the year. Additionally, one person is selected/agreed upon by the team as the point of contact person for all external communication with stakeholders and advisors. This avoids confusion for the stakeholder and requires individual and group accountability. Regarding group accountability, this fosters the development of leadership skills on how to best manage team expectations and group dynamics. Students are required to be reflective and write two short essays that address this. A sample of the assignment can be found in Appendix 1.

Experiential Learning: Selected Projects and Mandatory Weekly Meetings

This pedagogy is an umbrella term for forms of learning through experience and reflection.

As defined, these learning activities must be carefully structured and supervised. The capstone project process itself is the experience – it involves a real CG civil engineering problem/challenge that needs to be solved. The projects often include at least one specialty calculation or consideration that has not been a focus of our curriculum (ex: seismic design, airport runway design, etc.). Students must immerse themselves in the project, seek guidance from faculty advisors and stakeholders and learn the fundamentals of these new-to-them engineering design criteria. They are challenged and sometimes head in a direction that is not correct. To minimize their frustration and keep them on track, weekly meetings are held during the Spring semester of the course to ensure these tangents don't go on longer than a week. In the Spring, students have two-3hr blocks per week reserved on their schedule to meet with their advisors and work on their projects. The teams are required to meet with their faculty advisors at least once per week for a formal project meeting. Before each weekly meeting, the lead engineer for the week sends out an agenda. The agenda is based on a standardized template (see Appendix 2) developed by the course coordinator. As a team, the students are held accountable to develop an agenda, run the meeting and complete a written record (meeting minutes) of what was discussed. This process forces the team to reflect on their success and struggles for the week while also ensuring that they remain productive and on pace to complete the project on time.

Field-and place-based Learning: Mandatory Site Visit

Learning can take place anywhere, not only in a classroom or laboratory. Leveraging environments outside the classroom can significantly enhance student learning.

For every capstone team, students are required to plan and conduct a visit to the project site. The objective of this is to personally meet with the stakeholders on site to better understand the scope and expectations of the project. Prior to the site visit, students must research the history of the site and local area, typical causes of the engineering challenge they are facing (age of infrastructure,

changing climatic conditions, etc.), typical solutions to the problem and then formulate a list of questions about the project for the stakeholder. Typically, project problem statements and scope must be revised after the site visit. A site assessment report is completed as part of the project documentation. During the site visits, students have opportunities to interact with consultants and contractors, gain hands-on experience using non-destructive tools such as Ground Penetrating Radar (GPR), surveying equipment, rebound hammer, and other tools. This field-based learning experience resonates with students as they get to see the challenges themselves, employ several tools at their disposal to better understand and solve the problem, and realize that they can't solve the problem without the in-person site experience.

Inquiry-based Learning: Customer Design Development Brief

Inquiry-based learning is a form of active learning that places students at the center of the learning process. It begins with a problem that students must investigate. It involves some level of intellectual curiosity of students and this form of learning requires students to take responsibility for their own learning.

After the site visit, the capstone teams are then required to develop a "Customer Design Development Brief" (CDDB). Although the details of the brief depend on the type and nature of the project, the following list of suggested topics is provided to assist each project team.

- Summary of findings from site visit or desktop study
- Analysis of each pertinent finding
- Revised scope of problem statement
- List of planned deliverables at project completion
- Project production schedule – only items pertinent to stakeholders
- Expectations of each stakeholder – from designer point of view
- Recommended date for Interim Design Review by stakeholders

The CDDB is designed to mimic a professional site assessment report. In a professional setting, project managers are typically required to submit a site assessment report to stakeholders detailing findings from the visit and how they align with the research and/or assumptions leading up to the design process. The goal with the CDDB is to share the team's analysis of their findings with the stakeholders to align expectations of final deliverables. The CDDB familiarizes stakeholders with the planned design process for the project. Feedback from the brief typically provides clarification of the final scope and ensures everyone is on the same page. The goal is to agree upon a proposed course of action to prevent scope creep. The CDDB ensures that the student team can articulate the challenges at the site and ensures that stakeholders and the team are in alignment with the proposed path forward.

New Forms of Assessment: Specific Project Deliverables

Assessment through tools other than homework or exams. Includes authentic assessment that mimics professional practice and peer review.

For successful completion of the project, students are expected to generate several documents including detailed technical reports, design drawings and contract documents, depending on the requirements of the client. These documents are provided to the stakeholders for further project development. Emphasis is placed on following professional and technical guidelines and relevant codes, Coast Guard guidelines, and other specifications where applicable. Guidelines and deliverables for each project team include for example, a final comprehensive project report, a project notebook that demonstrates their progress throughout the semester (provided as a

reference to the sponsoring civil engineering unit or sponsor), a poster, two oral presentations of project status, and a final presentation to all stakeholders of the capstone project.

The variation in these assessment tools provides the student teams multiple ways and numerous opportunities to really learn the nuances of their projects. The culminating presentation and professional report provide the students with the opportunity to present their findings to audiences with a wide range of knowledge about engineering and their projects. The iterative process of the report also provides an opportunity for the team to learn and grow from their mistakes.

Enhancement of professional skills by these pedagogical changes

The changes that have been implemented were made with the intent to engage students more purposefully in their own learning and to ensure their success. As our students preferred method of receiving instruction has changed along with their increased willingness to dispute interpretations and call for the inclusion of alternate perspectives, we have modified and improved their culminating CEE capstone to encourage their learning while also more closely incorporating the project management skills our stakeholders expect. We provide our students with guidelines for key project milestones and suggested due dates, but we have left the specifics of managing their project up to them, meaning they need to work together as a team (manage conflict, reach consensus, etc.) to complete the project. They need to work collegially with each other and their stakeholders and utilize their leadership skills to motivate and manage each other. While the team deliverables have been standardized to provide a more thorough and consistent grading format across projects, we have created a more active, "do-it-yourself" approach to appeal to their preferred pedagogy. Guidelines and grading rubrics to ensure that each team understands the expectations have been standardized for the course and are provided for most of the deliverables. Most recently, we transitioned to requiring students to submit a 30%, 60%, 90% report in addition to the final project report. The trigger for this change was to offer project advisors more feedback opportunities to help improve students' technical writing and information literacy (IL) skills. Variations of a standardized rubric with several key components that assess writing and IL skills were used as shown in Appendix 3. A sample of the assessment data, shown in Figure 2, clearly indicates improvement for the Class of 2023 after adopting this change.

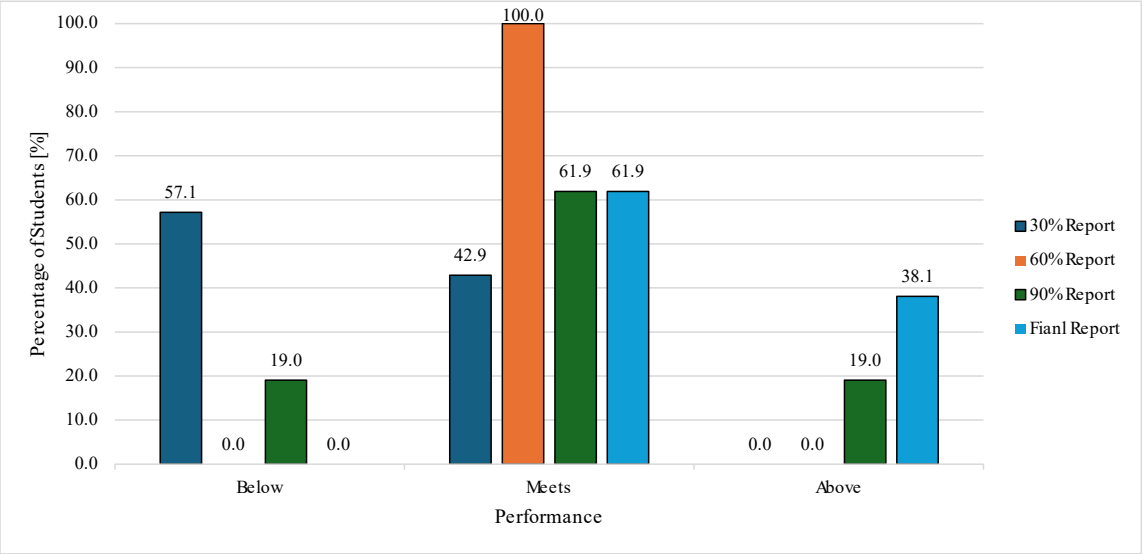

Figure 2: Student Performance on Writing Assignments

The CEE program will continue to monitor and assess the effectiveness of this change. Feedback from the stakeholders indicates the level of professionalism exhibited by each team has exceeded their expectations. Communication between faculty, students and stakeholders has improved which has resulted in the stakeholders receiving what they expect at the end of the project. In fact, several student projects over the past 5 years have been subsequently implemented by a Civil Engineering Unit or Facilities Engineering stakeholder. Students graduate with the confidence of being able to function in a team setting, communicate technical content to diverse audiences, and recognize the need to be life-long learners.

Conclusion

Over the past 20 years, the culminating design course at USCGA has grown and developed into a capstone program that delivers positive outcomes for both our students and stakeholders. A key graduation requirement of our program, students complete a capstone project that includes the application of teamwork, problem-solving, design, project execution and professional skills toward a real-life civil and environmental engineering problem. As the capstone experience has been improved and has morphed into the current two-course sequence that incorporates student centric pedagogical approaches, student professional skills have been improved and refined making the experience more meaningful for the student and more in line with what employers of professional engineers are seeking. By embracing pedagogical changes in the capstone course, the professional skills of leadership, teamwork and communication have improved for our students resulting in better alignment to the expectation of accreditors and the demands of employers. The goal of the capstone course is to deliver engineers to the workforce who are ready and able to meet the demands of the modern engineering profession. By embracing these pedagogical changes and incorporating them into our capstone course, the program has deeper connection to the students which improves their education and develops a cohort of engineers that meet the needs of the modern engineering profession.

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Appendix 1: Leadership Essay Assignment

Leadership Essay Assignment

Students will write two leadership journal entries throughout the semester. The objective of the assignment is to reflect on how leadership concepts apply to the project and team experience. Because of the nature of this assignment, outside sources are not required. However, students are encouraged to make use of all available information, including work done as a part of your Leadership Development in various academic courses, summer training programs, and general military training.

Essay Expectations:

Your first essay should, at a minimum, include:

- A description of how you plan to approach your project from a leadership perspective;
- An analysis of how this plan may differ from a more traditional leadership role due to the nature of the project/nature of the group you are working in;
- Explanation of at least two leadership challenges you anticipate facing during the project, and how you intend to overcome those challenges;
- What you intend to learn from this experience (in terms of leadership).

Your second essay should, at a minimum, include:

- A brief summary of your first essay;
- Leadership lessons learned from the project;
- A reflection on how you can make use of this experience in future situations.

Timeline:

- January 19th – Essay #1 due
- April 6th – Essay #2 due

Grading Criteria: You will be graded on the following:

- Quality of writing
- Depth of insight/reflection
- Meets criteria set forth in assignment description
- Grammar
- Organization of entry

Format:

Written work should be 2-3 pages in length, double-spaced, Times or Times New Roman 12-point font.

Referencing:

All sources must be properly cited in the text and must be listed at the end of the journal using the ASCE journal guidelines.

Submission:

Submit essay via OneNote by 0800 on the assigned due date.

Collaboration:

Students may only consult with the course Instructor, any other Faculty member, or cadet Writing & Reading Center Staff when researching and writing Journal Assignments.

Civil Engineering Design:
Leadership Essay Grading Rubric

STUDENT NAME: _____ ESSAY NO._____

Writing Assessment Criteria	**Exceeds Expectations (90 to 100%)**	**Meets Expectations (70 to 90%)**	**Below Expectations (Below 70%)**
Demonstrates good technical writing skills, organization, and ability to follow prescribed format. **Score _____/20**	Writing is clear, well organized, concise, and easy to understand. Sentences are grammatically constructed. The appropriate written voice and tense is used. There are very few typos or spelling errors.	Writing is easy to understand with few unclear or poorly constructed sentences. There are a few typos or spelling errors.	Writing is of poor quality and not cohesively organized. Ideas are not clearly explained. There are many grammatical errors and/or typos.
Content **Score _____/20**	Demonstrates clear understanding of assignment. Includes detailed insight into each assignment prompt: **leadership perspective** or **approach** for the given setting; explanation of potential or realized **leadership challenges;** how **challenges** will be or were **overcome;** and **expected** or **actual lessons learned** explained.	Demonstrates sufficient understanding of assignment. Each assignment prompt covered in some detail. Adequate insight provided.	Writing shows lack of understanding of assignment. Assignment prompts not fully covered and/or lack of sufficient insight.

TOTAL: / 40

Comments:

Appendix 2: Standardized Meeting Minute Template

Routing Checklist:

- Lead Engineer (*Individual grade assigned*): xxxxx
- Forward Agenda via email to Advisors & Team 36 – 48 hours before meeting. (Cc course coordinator for assignment tracking – 1 Point Lost for late submittal)
- Send Meeting Minutes via email to Advisor & Team within 24 hours of meeting. (Cc course coordinator for assignment tracking – 1 Point Lost for late submittal)

Grading Rubric (10 Points):

- Meeting facilitation – ***3 Points*** (Advisor assessed)
- **Meeting professionalism – *3 Points* (Advisor assessed)**
- **Report professionalism – *4 Points* (CED Instructor assessed)**

MEETING MINUTES #

PROGRESS REPORT: Date

Project Title: USCG Station Noyo River Seawall Design

ATTENDEES

Advisor	Dr. Jackson and CAPT Maggi
Lead Engineer	
Team Member	
Team Member	
Team Member	

PROJECT STATUS

% complete to Date:	
Estimated budget	**Pending**
Days until presentation dress rehearsal (April 25, 2024):	
Days until final presentation (May 2, 2024):	
Days behind/ahead of schedule:	**0 days behind/ahead**
Hours spent working on the project since the last meeting	
(Count hours individually)	
Productivity per Week (*Change in % Complete / Hours Spent)*	
Meeting Duration	

MEETING AGENDA

Include agenda items for this week here.

DISCUSSED ISSUES

Include items discussed at meeting. Note responsibilities and timelines.

One Week Look Ahead **(include personal commitments that may impact schedule)*:***

Clarification Issues

1. **Issue**:
   Resolution:

Assignments

Upcoming Events **(include items that will impact Class/Lab)*:***

Appendix 3: Report Grading Rubric

Civil Engineering Design (CED) – 1402

CAPSTONE Final Report Grade Sheet

Project Title: _____

Cadet(s): _____

Report Content Assessment	Comments	Exceeds Expectations (90 to 100%)	Meets Expectations (70 to 90%)	Below Expectations (below 70%)
Quality of the executive summary. **Score _____/10**		Includes a summary of problem statement and objectives, a summary of methods and materials as applicable, a brief discussion of design alternatives considered, an explanation of why the final design was chosen, a brief description of the final design, and a brief conclusion and recommendations.	Executive summary is complete except for one or two missing items.	Executive summary is missing 3 or more items.
Quality of the introduction. **Score _____/10**		Introduction includes background, a good problem statement, and clearly articulated and appropriate objectives.	Introduction includes background, problem statement, and objectives that are mostly appropriate and complete.	Introduction does not contain adequate background, problem statement, and/or objectives to properly explain the project.
Quality of literature review. **Score _____/10**		All theory, similar projects, and research is clearly discussed and appropriately supports the scope of the project.	Noted items in "Exceeds Expectations" are described. Only minor omissions are noted.	Noted items in "Exceeds Expectations" are poorly described and there is a lack of references.

Report Content Assessment	Comments	Exceeds Expectations (90 to 100%)	Meets Expectations (70 to 90%)	Below Expectations (below 70%)
Methodology and identification of design alternatives. **Score _____/20**		Criteria / constraints and design alternatives are discussed. A sound and complete method (i.e. a decision matrix or other process) is used to select the final design. If appropriate, lab and field work is described	Criteria / constraints and design alternatives are discussed but not in great detail. A method for selecting a final design (i.e. a decision matrix or process) is used with minor errors or omissions.	Criteria/constraints are not presented and/or design alternatives are not identified. The method for selecting an alternative is unclear, illogical, or incomplete.
Quality of findings and discussion of selected alternative. **Score _____/30**		Includes results of lab procedures, fieldwork, and design work (with any pertinent calculations). Design is detailed and professional with all drawings completed in AutoCAD.	Includes most results of lab/field work and basic design work. The design is presented with only minor details missing and/or minor problems with AotoCAD drawings.	The section is lacking important and/or significant results of lab/field work or design work. Drawings are not clearly presented in AutoCAD and/or the design is missing important details.

Quality of conclusions and recommendations. **Score _____/20**		The final design is discussed in the context of the problem statement and project objectives. Four or more recommendations are made for additional work and/or future issues to address.	The final design is discussed as related to the problem statement and most of the project objectives. At least 3 recommendations for additional work and/or future issues are presented.	The chosen design is not related to the problem statement and objectives. Less than 3 recommendations are made.

Information Literacy Assessment	**Comments**	**Exceeds Expectations (90 to 100%)**	**Meets Expectations (70 to 90%)**	**Below Expectations (below 70%)**
Demonstrates an ability to conduct the scope of research needed to support the project. **Score _____/10**		The scope of research conducted strongly supported all of the areas of the project.	The scope of research conducted was adequate to support most areas of the project.	The scope of the research conducted did not adequately support important areas of the project.
Demonstrates an ability to incorporate a variety of appropriate technical information sources. **Score _____/10**		Fifteen or more appropriate technical information sources are used representing 4 or more types of sources (i.e. technical books, reports, web sites, journal articles, design manuals etc.). There is not over reliance on a few sources.	At least 12 appropriate technical information sources are used that represent at least 3 types of information sources. There is not over reliance on one or two sources.	There are less than 12 technical information sources used and/or some sources are inappropriate for a technical research paper. There is over reliance on one or two sources.
Demonstrates an ability to use sources appropriately, legally, and ethically. **Score _____/10**		Sources are properly paraphrased and all direct quotes are in quotation marks. References are cited properly within the text and are appropriated listed in a bibliography at the end of the paper according to the ASCE referencing guidelines.	Sources are properly paraphrased and direct quotes are in quotation marks except for minor issues. References are in the bibliography using the ASCE referencing guidelines and references are properly cited with only minor issues.	Sources are not properly paraphrased and/or direct quotes are not properly attributed. Citations are missing from the text and/or are not properly listed in the bibliography according to the ASCE referencing guidelines.

Technical Writing Assessment	Comments	Exceeds Expectations (90 to 100%)	Meets Expectations (70 to 90%)	Below Expectations (below 70%)
Demonstrates sound technical writing skills. **Score _____/10**		Writing is clear, concise, and easy to understand. Sentences are grammatically constructed. Passive voice is used. There are very few typos or spelling errors. Tables and figures are numbered and properly incorporated into the text. Appendices are used appropriately.	Writing is easy to understand with few unclear or poorly constructed sentences. There are a few typos or spelling errors. Tables and figures are properly used and incorporated and appendices are properly used with only minor issues.	Writing is of poor quality. The concepts are not clearly explained. There are many grammatical errors and/or typos. Tables and figures are not numbered, properly incorporated into the text, and/or introduced.
Demonstrates an ability to write well-organized text and follow technical report format. **Score _____/10**		The report follows the prescribed format and is well organized within each section. Content is presented in a logical and methodical fashion.	The report follows the prescribed format with only minor issues. The report is fairly well organized within each section.	The report does not follow the prescribed format and/or is poorly organized.
Total Score **_____/150**	Summary Comments			