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Implementing an Interdisciplinary Senior Design Approach Within a Traditional Departmental Framework

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Abstract

Engineering careers have become increasingly collaborative and multidisciplinary. To better prepare students for this climate, the Engineering School faculty and staff at The Cooper Union for the Advancement of Science and Art have undertaken an initiative to improve interdisciplinary collaboration in senior capstone design projects. Interdisciplinary projects provide opportunities for students to collaborate across disciplines on complex problems and strengthen ties between departments and faculty. We have endeavored to maintain the independence of departmental capstone courses while still encouraging and facilitating interdisciplinary collaboration. We formalized the advising and assessment structure between departments and adjusted the course schedule to have all departments' capstone courses meet at the same time each week to allow common workshops, presentations, and assessments. Over the last three years, 84 students (25% of total students) on 23 teams have participated directly in such interdisciplinary projects, with various degrees of collaboration. All engineering seniors, regardless of whether they are on an interdisciplinary team, participate in team formation exercises, unified workshop sessions, and an "Interdisciplinary Capstone Showcase" poster or oral presentation in the fall and the spring. In an end-of-the-year survey, a vast majority of students stated that they thought it was "important" or "very important" for future students to have the option of participating in an interdisciplinary project. Additionally, a majority of students on interdisciplinary teams indicated that this participation helped their learning and contributed to the success of their projects. These results are supported by student survey responses, student assessments of learning gains and teamwork evaluations.

Introduction

As the world becomes increasingly global, complex, and intertwined, engineering careers have become ever more collaborative and multidisciplinary. The grand challenges facing our planet require interdisciplinary approaches, and therefore so should undergraduate engineering projects [1]. To this end, beginning in the summer of 2022, faculty teaching senior capstone design at The Cooper Union for the Advancement of Science and Art implemented an interdisciplinary approach to their courses. Previously, interdisciplinarity was allowed, but not formally supported. For this initiative, due to the constraints of each ABET accredited major's capstone requirements and established assessment processes, the faculty elected to maintain departmental courses, while still facilitating and encouraging interdisciplinary projects.

The benefits of collaboration across disciplinary lines have been well studied. These include increased readiness for the complexities of real-world problem solving and preparation to work in emerging interdisciplinary fields such as robotics or sustainability [2], [3]. Students engaged in interdisciplinary projects tend to be more interested, committed, and expect more quality out of their projects [4]. Many case studies have been conducted around interdisciplinary capstone projects, some involving engineers of different disciplines [5], [6], [7] and others also involving non-engineers [8], [9]. These courses have a wide range of project types, amounts of project

scaffolding, and requirements. Often these studies include a separate course and structure for those involved to facilitate these new projects.

ABET requires that an accredited engineering curriculum include 'a culminating major engineering design experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work' [10, p. 7]. At The Cooper Union, this takes the form of departmental capstone design courses. These courses allow the individual major departments to control the student experience and ensure that ABET requirements are fulfilled, particularly in demonstrating prior course knowledge. While many other schools have created separate courses for interdisciplinary work [6], [8], this was not desirable or feasible at The Cooper Union at this time. Therefore, the faculty created a framework to allow interdisciplinary projects without requiring the development and approval of a separate course structure.

The contribution of this work is the redesign and assessment of the implementation of interdisciplinary capstone projects within a traditional departmental framework. Each major department runs its own independent capstone design course. To encourage and facilitate collaborative projects within this framework, the instructors provide a formalized structure for team and project formation and for faculty advising. Major assessments have been aligned between departments so students participating on an interdisciplinary team do not have extra work to complete. Additionally, a common course meeting time has allowed for workshops, presentations, and poster sessions to incorporate students of all disciplines. Pre-semester surveys were conducted to assess interest in participation and end-of-semester surveys were used to assess the efficacy of the initiative.

Background – Existing Senior Capstone Design Structure

At The Cooper Union there are three schools – the School of Engineering, the School of Art, and the School of Architecture. Within the Albert Nerken School of Engineering, there are four ABET accredited majors – chemical engineering (ChE), civil engineering (CE), electrical engineering (EE), and mechanical engineering (ME), and a non-accredited (Bachelor of Science) in general engineering major (BSE). Note that beginning in 2025-2026, the BSE major will no longer be available, and a Computer Science major will be offered. There are usually about 25-30 students in each of the four accredited engineering majors per year. Until this initiative, each department independently ran their capstone course, with very little interdepartmental communication between instructors or students. Throughout this initiative, more collaboration has taken place between departments, but there are still four separate capstone courses, each with its own structures, objectives, assessment and requirements.

As the capstone experience is a culmination of the curriculum, each department uses its course as a key place to evaluate the ABET student outcomes as outlined in Criterion 3 [10]. Table 1 presents the ABET outcomes that are currently assessed using performance indicators in each department's respective capstone course. Those outcomes not indicated are often still demonstrated in the capstone course but are formally assessed elsewhere in the curriculum.

Table 1. Performance Indicators in Capstone Courses for Assessment of ABET Outcomes (1)-(7)

	ChE	CE	EE	ME
ABET (1) - Problem Solving		x	x	x
ABET (2) - Engineering Design	x	x	x	x
ABET (3) - Communication	x	x	x	x
ABET (4) - Ethics & Professional Responsibilities	x	x	x	x
ABET (5) - Effective Teams	x	x	x	x
ABET (6) - Experimentation			x	x
ABET (7) - Lifelong Learning		x	x	x

The electrical and mechanical engineering capstone courses feature open-ended projects, while chemical and civil engineering capstone courses are more structured experiences. Civil, electrical, and mechanical engineering courses are full year experiences working on a single project. The chemical engineering courses also span a full year but include multiple projects. General engineering students are not required to complete a capstone course but sometimes choose to participate in the capstone experience. The differences in structure and in assessment between departments have required careful planning for interdisciplinary collaboration, as making a separate, interdisciplinary course was not currently feasible.

Both the electrical engineering senior capstone course and the mechanical engineering senior capstone course allow students to choose their own teams and to develop their own projects (with faculty approval). Each project is required to solve a real-world design problem. This leads to a broad range of projects each year, from assistive medical devices and machine learning algorithms to aerospace engineering competitions, self-driving vehicles, and radio modules. Specific project deliverables vary according to the nature of the problem but must include background research or market research, proposed design solutions, comprehensive analysis of the selected solution using appropriate tools, and evaluation of a working prototype. Students are also required to maintain thorough documentation throughout the year.

Despite the similar project structure, the advising and faculty structure varies between mechanical and electrical engineering. In mechanical engineering, many of the full-time faculty are formally involved in instructing the single section of the course. Because in-class meeting time, particularly in the fall semester, is often used for design-related skill-building workshops, students are expected to set up a regular meeting time with their advisor(s) outside of class. In electrical engineering, the course is split into two sections, with each section instructed by one faculty member. Advising meetings are typically conducted during course meeting times rather than outside of class. To accommodate the variety of projects, students are made aware of the various resources available to them on campus and, in some cases, outside of campus and are encouraged to pursue them based on their project's needs. Design reviews and updates occur on a weekly basis.

The chemical engineering capstone courses make up a year-long sequence but focus on different aspects of chemical engineering design in each semester. In the fall, the first course focuses on creating flow diagrams, equipment design, economics, process safety, and optimization of manufacturing equipment. The spring course focuses on the conceptual design of two chemical manufacturing facilities; the first is a large-scale ethylene cracker where students work actively in class with the instructor while modeling the plant in a process simulator. The second project serves as the capstone, where students work independently on creating their own design from a prompt as a group of "consultants." Students scope, site, design, simulate, evaluate, and cost their chemical manufacturing facility and give a quantitative conclusion about its overall safety, sustainability, and economic value. The 2023 and 2024 projects asked students to design a brewery to make beer with carbon sequestration by turning the spent grain into biochar. Previous projects included designing facilities to manufacture COVID vaccines, ammonia, hydrogen, and various biofuels. During the second project, in-class time is primarily spent on student presentations, where they present their progress as they work through the design process.

The civil engineering senior capstone course requires that students, working in teams of four, select realistic projects, using a site and a set of needs, objectives, constraints, and criteria. Projects must involve real people such as the owner, the engineer, the contractor, and the community. In the first semester, students select a site that they can physically visit, propose a project on that site, and conduct feasibility studies. They then develop conceptual designs, considering environmental impact, economic factors, financing, health and safety, reliability, aesthetics, ethics, and social impact to select a final design. In the second semester, students develop their final design, including detailed system descriptions, planning and scheduling, constructability, cost estimates and financing. Students must collect all the data pertinent to the project, including community reaction, building code requirements, environmental impacts, construction costs, climate data, necessary building permits and sustainability issues of their design. During class time, the designated instructional faculty (both full time and adjunct senior professional engineers), deliver lectures on these topics and closely advise students on their designs. There is a strong emphasis on interfacing with outside civil engineering practitioners who are specialists in each of the different project phases and on exposing students to the latest standards of professional practice.

With the wide variation in project type, level of structure, and assessment between departments, it was not deemed practical at this time to create a separate interdisciplinary course to satisfy all departments. Instead, the faculty decided to work within these structures to facilitate interdisciplinarity while allowing students to remain enrolled in their departmental course.

Project Approach

The goal of this project was to implement and support interdisciplinary senior capstone projects without eliminating department-specific capstone courses. With the support of the administration, the School of Engineering formed an ad hoc committee with faculty representatives from each major department in the summer of 2022 to discuss this implementation. The committee proposed a common meeting time for all classes, including a dedicated interdisciplinary hour with corresponding classroom space. A more formal shared advising structure was also proposed, and a list of initial interdisciplinary project ideas was

compiled. Additionally, major assessments throughout the year, both written and oral, were synchronized and interdisciplinary end-of-semester and end-of-year showcase events were developed and implemented.

After examining the structure, format, and project types of each department's capstone course, the faculty recognized that design teams which include electrical engineers and mechanical engineers had the most opportunities for collaborative projects, as both EE and ME have open-ended projects with strong problem definition requirements. Therefore, the instructional faculty and students in these departments have collaborated and organized more extensively than the other departments. As currently implemented, civil engineering capstone projects are significantly more scaffolded, as they require the design of a structure (building, bridge, etc.) and must include substantial design in at least two of the four civil engineering disciplines (Foundations, Structures, Environmental or Water Resources) as part of the curricular requirements. Thus, incorporating CE students into interdisciplinary projects has increased requirements when compared to EE or ME, but projects such as Solar Decathlon and other smart building projects have provided opportunities to collaborate across these disciplinary boundaries. Similarly, chemical engineering capstone projects are not chosen by the students and must contain a process design component, rather than product or structure design, which puts an extra restriction on how ChE students can participate. For this initiative, interdisciplinary projects were not able to replace the ChE capstone courses, but ChE students interested in interdisciplinary projects were offered the opportunity to earn independent study/elective credit for them.

The faculty instructors have implemented these new strategies during the three most recent academic years. Implementation required significant ongoing communication and collaboration between instructors to facilitate deliverable alignment, giving feedback, and conducting assessments. During each interdisciplinary meeting session, the instructors discuss team progress and current and future planning. Additionally, a separate Microsoft Teams channel is used for faculty communication.

Project Development and Advising

For students to form interdisciplinary teams, they must have a facilitated chance to discuss project ideas. During the summer prior to the senior year, a document with brief project topic descriptions proposed by the faculty is circulated to the students. This document is a collaboration between faculty in all four departments, with advisers from each relevant department explicitly listed. A non-anonymized survey is also conducted to assess students' interest in participating in an interdisciplinary project.

Students are asked to indicate their interest in participating in an interdisciplinary capstone team. They are then presented with a list of ongoing or planned project ideas, such as Solar Decathlon, carbon negative beer brewing, or CubeSat, and asked to indicate their interest on a Likert scale of one (not interested), two (maybe interested), or three (very interested). Using the same scale, students are also asked to indicate their interest in broad, interdisciplinary topics, including Mechatronics and Robotics, Sustainability and Environmental Engineering, Bioengineering/Biomedical Engineering, and Aerospace, among others. Additionally, there are

open-ended questions on the survey, asking students to elaborate on their interest in the topics they selected and to list additional ideas or topics for projects. These answers are used to connect students who are interested in the same topics and to help them form teams.

Informed by the results from the survey, the first interdisciplinary meeting of the semester is dedicated to team formation. Faculty introduce the course and emphasize the importance of interdisciplinary work. Broad project topics are posted around the lecture hall, and students are directed to approach the topics they are interested in and discuss their ideas with the other students. Students are also allowed to propose their own ideas, but these projects must be approved by faculty. As teams begin to form, those groups looking for additional team members, or those that the faculty feel would benefit from interdisciplinarity, are encouraged to present an informal short pitch of their project to their peers.

Students are required to have at least one adviser from each major department represented on their team. Currently, each department handles advising differently, with some opting to use the scheduled course time for advising meetings while others schedule separate meetings outside of course time with teams. The faculty has been flexible with allowing students to attend in-class meetings in another discipline or by attending external advising meetings themselves. Though students are formally advised and evaluated by each individual department's faculty, for interdisciplinary projects, the instructors meet and consult with the other disciplines' faculty to discuss the work and contributions of the individual team members. This is used as an input for evaluations and grading.

The exact nature of collaboration between students differs based on the project and makeup of the team. Electrical and mechanical engineering teams often work very closely together on a fully integrated project, sharing tasks and goals. Teams that involve civil engineers are often more loosely connected, as the civil engineers must complete specific structural design tasks. For example, the civil engineering project may focus on designing a performance space while the electrical or mechanical engineers are designing an exhibit. Thus, the outcomes and tasks are different between the disciplines, but they may treat one another as clients or stakeholders and consider how to integrate and align their goals.

Common Time, Workshops, and Space

To better facilitate interdisciplinary projects, the faculty recognized the need for a common class meeting time for all four majors' capstone courses. Previously, each department's assigned three-hour course time was independently scheduled. Of the new, common three-hour period, at least one hour each week is set aside for interdisciplinary work, with a dedicated lecture hall reserved. During this time, students interact with peers of all majors, students present their project work, and unified skill workshops are held. This interdisciplinary hour is reserved every week but is not always used.

Prior to this initiative, students on an interdisciplinary team were required to present independently to each departmental course. This often resulted in fully separate presentations, depending on each course's requirements as discussed in the Alignment of Deliverables section. Often, only the part of the team corresponding to the department was able to attend each

presentation, and faculty advisers from the other departments were unable to attend. Additionally, students only received feedback from faculty and peers in their own department. With the capstone redesign, students participating in interdisciplinary teams have a common presentation time as a full team, presenting to a diverse set of peers and faculty from multiple departments. Additionally, this time allows students and faculty to attend presentations scheduled in other departments, such as mechanical engineering students attending the civil engineering end-of-semester presentations.

The interdisciplinary time is also used for unified workshops and social events. At the start of the school year, the time is used for interdisciplinary team formation. Additional workshops during this common time have included sessions on creating an effective poster, and manufacturing/fabrication sessions. Both workshops are sufficiently broad to have interest from multiple departments and are structured in such a way that students get direct experience applying the topics to their own projects and receiving live feedback. Social events are held once a semester and include ice cream socials, visits to exhibits elsewhere on campus, and field trips. These events serve to strengthen the bonds across departments between students and faculty who don't often have a chance to interact.

In addition to a common class meeting time, we also provided additional physical space, in the form of a dedicated interdisciplinary design space. While this space is shared with the first-year interdisciplinary design course in the fall, in the spring it is fully dedicated for capstone. The room is intended for brainstorming, early prototyping, and final assembly. This room provides a workspace for interdisciplinary and non-interdisciplinary capstone projects as well as assembly and storage space for prototypes.

Alignment of Deliverables

One of the primary problems with the previous ad hoc support of interdisciplinary projects was the misalignment of primary assessment schedules and a lack of cohesiveness in expectations. After analyzing the pre-existing departmental capstone assessment schedules, as presented in the top half of the schedules in Figure 1, the faculty recognized that, while the learning objectives were common across departments, the schedule and form of deliverables were not. This resulted in students on interdisciplinary teams being required to submit multiple versions of assignments and presentations. As the previous deliverables were often very similar, the faculty agreed to align both the schedule and the requirements for interdisciplinary teams, as shown in Figure 1. As the civil engineering course is more structured, their participation in this alignment was limited to team formation, major presentations, and some written reports. Chemical engineering students opting to participate in interdisciplinary projects (as an independent study/elective) can attend and contribute to the major deliverables of their peers' courses. Additionally, some departments have slightly shifted or altered deliverables for non-interdisciplinary teams to better match the interdisciplinary track.

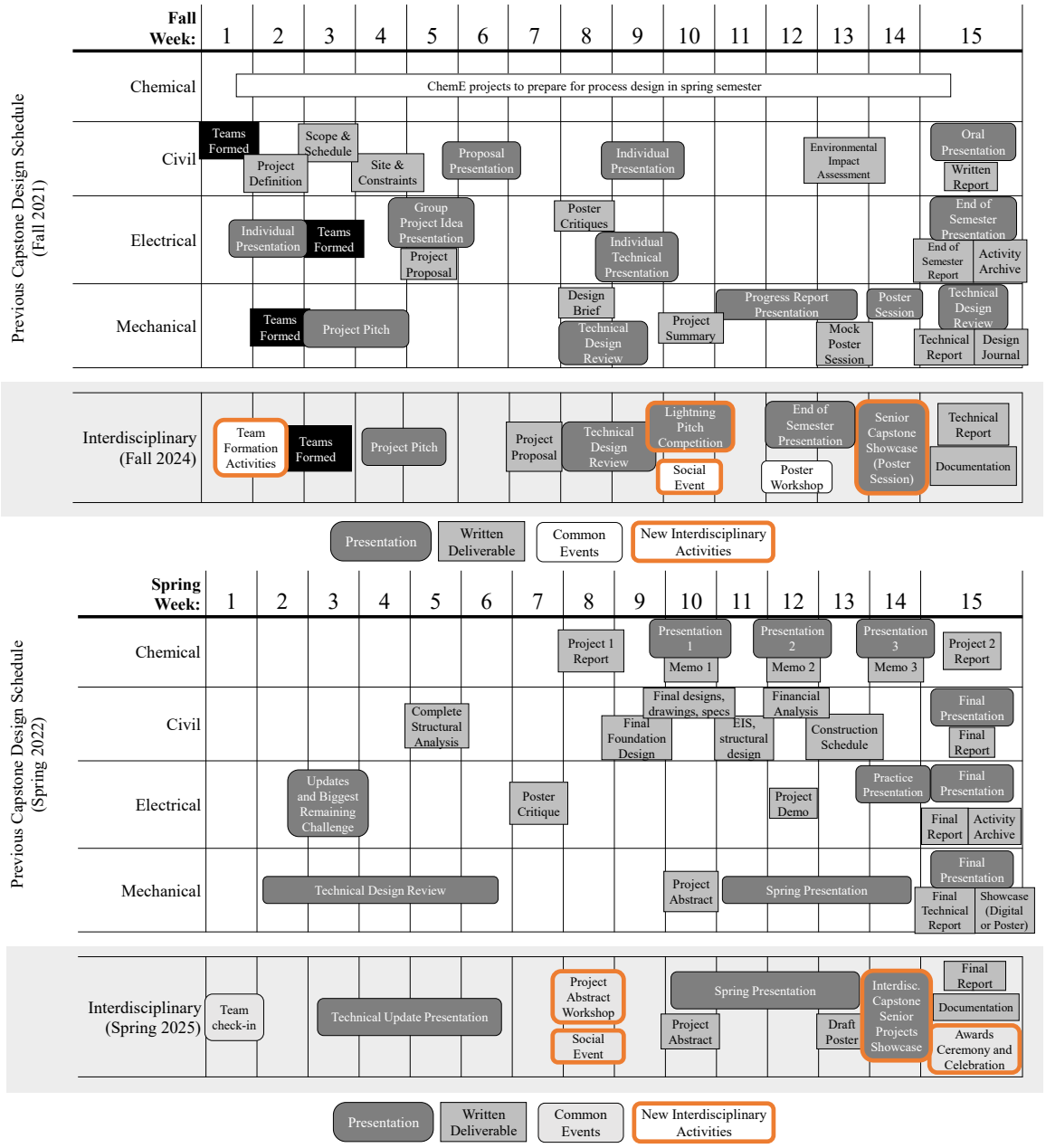

Figure 1. Capstone assessment and activity schedule for fall (top) and spring (bottom) semesters before and after formal interdisciplinary support. Note that interdisciplinary teams in ME and EE follow the interdisciplinary schedule and CE and ChE participate to varying degrees.

Written reports, including the project proposals and end-of-semester reports have been aligned between the electrical and mechanical engineering departments. The expectations were previously similar between departments but required slightly different information and formatting. The updated mid-fall semester project proposal must include project motivation, background research, a clear problem statement, functional requirements, a functional diagram, and design constraints, including codes and standards. At the end of the fall semester, an interim report is required of all teams, with no page limit. They must include the material from the

project proposal, as well as any information on their current design process (including any designs and decisions, prototypes, and testing plans). In the spring, the report takes the form of a professional conference paper. Teams may choose the most relevant professional conference format (IEEE, ASME, etc.). This requirement requires students to concisely present their work and gives teams wishing to submit their work to these conferences a head start.

To supplement the final reports, students are also required to provide consistent documentation throughout the semester. They are expected to develop a comprehensive repository such that a future group could pick up where they left off. Additionally, this documentation is a way to track student effort and teamwork throughout the year. The form of the documentation is not prescribed, allowing variations between departments and between teams.

After midterm presentations in the fall semester, a "lightning pitch" competition is held for all mechanical and electrical engineering projects, regardless of interdisciplinarity. In this session, students prepare a one-minute pitch of their project to present to their peers, the capstone faculty, and a panel of invited guest judges. This activity requires students to distill their project idea down to a succinct statement and present it clearly to a wide audience. They are encouraged, but not required, to be creative. Several pitches have taken the form of songs, poems, skits, and more. Prizes are awarded by the judges and by audience choice based on how engaging the presentation is and how compelling the project is. This activity is followed by a social event for all majors.

Interdisciplinary Senior Capstone Showcases

The alignment of scheduling has allowed for the creation of an Interdisciplinary Senior Capstone Showcase in both the fall and the spring semester. These public events allow students to demonstrate their work to a wider audience – faculty, their peers, more junior students, alumni, and visitors. In the fall, this takes the form of a poster session, with electrical, mechanical, and interdisciplinary teams participating. In the spring, all departments participate. Each team prepares an 80-word project summary to be featured in promotional materials and on a showcase website. Civil, electrical, and mechanical engineering host a poster and demo session, while chemical engineering has presentations. Thus, this is a combined event without the need to fundamentally change the format of individual departmental assessments.

After the spring Showcase, the faculty hold an awards ceremony for all seniors, which includes an end-of-year celebration with food and drinks. Awards are presented for the best capstone projects in each department, best interdisciplinary project, best showcase demonstration, and others as chosen by instructors. Prizes may include money, school swag, or gift cards. The awards are also included in the commencement program.

All Capstone projects are documented on a new, dedicated website (capstone.cooper.edu). Project titles, summaries, and team members are included unless students opt out. Students are encouraged to grant permission to share images or final posters on this website as well. Some teams also choose to link to videos, custom websites, or code repositories.

Assessment and Surveys

At the end of each semester, instructors created an anonymous survey to evaluate student experiences. This serves two main purposes – to gain immediate feedback to improve the course and to evaluate the efficacy of the interdisciplinary initiative. This survey was distributed to all students enrolled in an engineering capstone course, regardless of their participation on an interdisciplinary team. The students were first asked to answer questions about their major, the extent to which they participated in the interdisciplinary capstone experience, and which other majors they worked with if they were part of an interdisciplinary team. They were then asked to give feedback on their experiences, including Likert-scale questions and open-ended feedback prompts.

Results

The interdisciplinary capstone initiative was evaluated by both direct and indirect assessment methods. In addition to evaluating capstone projects using traditional departmental outcomes assessment, all seniors, regardless of whether they participated in an interdisciplinary project, were surveyed to gather feedback on their experience and the perceived importance of the opportunity to work on an interdisciplinary project.

Participation

Over the course of the three academic years of this initiative, there have been a total of 343 seniors in all five departments in senior capstone courses. This includes general engineering students (BSE), who are not required to enroll in a capstone course. 84 students, or 25% of seniors, have participated directly on an interdisciplinary team. Figure 2 presents the breakdown of this participation by year and discipline. Several teams have also collaborated with students in art or architecture programs. Those students are not included in the total student participation or surveys. Prior to this initiative, there were typically two or three interdisciplinary projects per year. There has been an increase in student participation since the launch of this initiative.

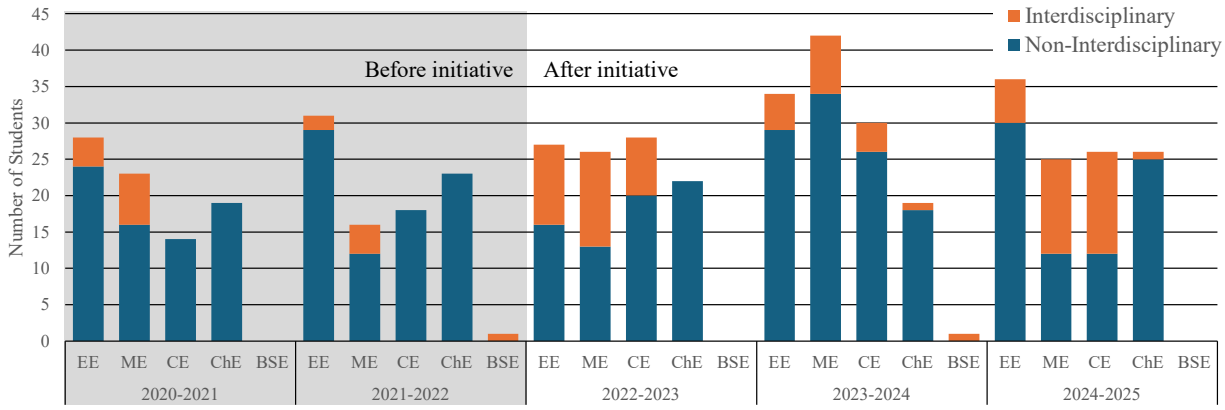

Figure 2. Student participation in interdisciplinary projects before and after the initiative was implemented.

In the first year of the initiative, 2022-2023, there were 10 interdisciplinary projects. In 2023-2024, there were six interdisciplinary projects, and in 2024-2025, there are seven interdisciplinary projects. Twelve of these projects have been collaborations between only

electrical and mechanical engineering students. These projects have included an algorithm for preference-based path planning for autonomous robots, a voice-activated chess board, a grid-tie inverter, and a modular aerial seeding system. Collaborative teams between civil engineers and mechanical engineers and/or electrical engineers have worked on the Solar Decathlon competition (also including architecture students), a livable last-mile delivery facility and vehicle, and acoustics for the built environment. Chemical engineering students have participated in projects with civil, electrical, and mechanical engineers on a carbon neutral beer brewery project and on the AIAA Design Build Fly competition. A handful of projects have also involved art students and faculty, including AI text generation and an interactive somatic sound system.

Pre-semester Interest Survey

A pre-survey before the school year was given over the last three years (2022-2024). 194 students responded, a 57% response rate from ABET-accredited programs of civil, chemical, electrical, and mechanical engineering. Although capstone projects are optional for general engineering students, they were invited to participate as well. As shown in Figure 3, 87% of students surveyed indicated they "might be interested" or were "very interested" in an interdisciplinary senior project. The results indicate that students' interest in an interdisciplinary project largely depends on the project, topic and/or teammates, but that students are open to working on this type of project. Future work will be to examine what factors determine whether an interested student chooses to work on an interdisciplinary team.

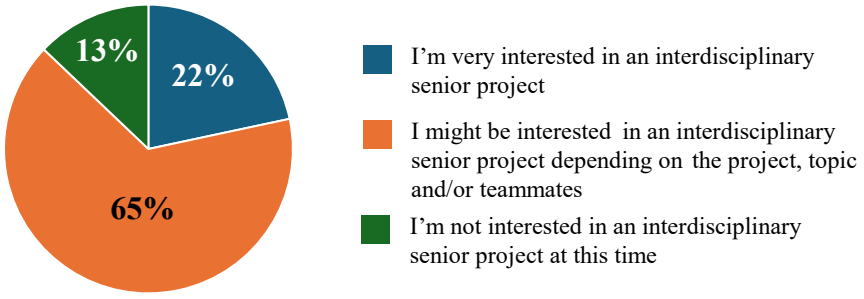

Figure 3: Percentage of students interested in interdisciplinary capstone projects (194 survey respondents from 2022-2024; response rate of 57% of total seniors in ABET accredited majors)

End-of-Semester and End-of-Year Surveys

Seniors were surveyed at the end of the semester in Spring 2022, Spring 2024, and Fall 2024 to gather feedback about their capstone experience. 29% of seniors (101 in total) took the survey, and 40 survey respondents (a 48% response rate) participated in an interdisciplinary team. As shown in Figure 4, the majority of students on an interdisciplinary team felt the interdisciplinary experience contributed "a fair amount" or "a great deal" to the success of their project. 88% of these students said the dedicated interdisciplinary block time and interdisciplinary advising helped their learning and 90% said working with students from other majors helped their learning. Thus, through interdisciplinary elements incorporated within the departmental courses, we were able to provide a beneficial experience for students without needing to create a dedicated interdisciplinary course.

While most students felt that working with students and advisors from other departments aided their learning, there were mixed opinions on some of the implementation. Half of the interdisciplinary team participants said the expectations for project deliverables were aligned "a fair amount" or "a great deal", only 41% said the timelines of deliverables were aligned "a fair amount" or "a great deal" and even fewer indicated that the dedicated interdisciplinary time block helped their learning. This implies that there is further work to better communicate and align assessments and deliverables as well as effectively using the common time block.

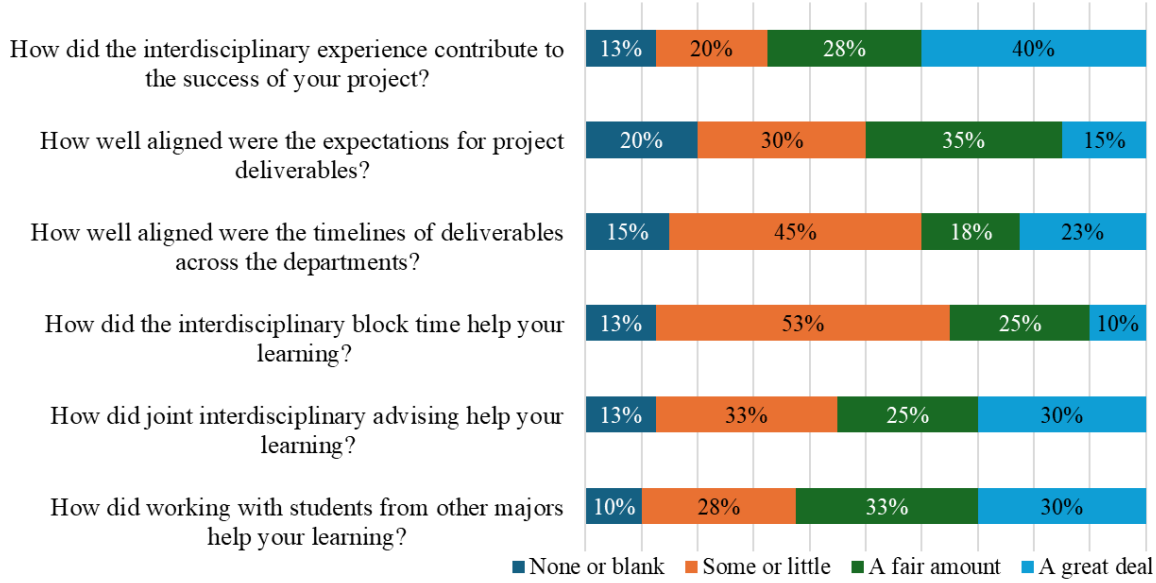

Figure 4: Interdisciplinary Senior Project Experience Feedback Survey Results (40 responses from students on interdisciplinary teams in Spring 2023, Fall 2023 and Spring 2024)

All students, whether they participated on an interdisciplinary project or not, were surveyed on the importance of the option to participate in an interdisciplinary capstone experience. As shown in Figure 5, 90% of students said that it was "very important" or "somewhat important depending on the project, topic and/or teammates". Figure 5 also shows the breakdown of interdisciplinary team students who all responded that the option to participate on an interdisciplinary project is "somewhat" or "very" important.

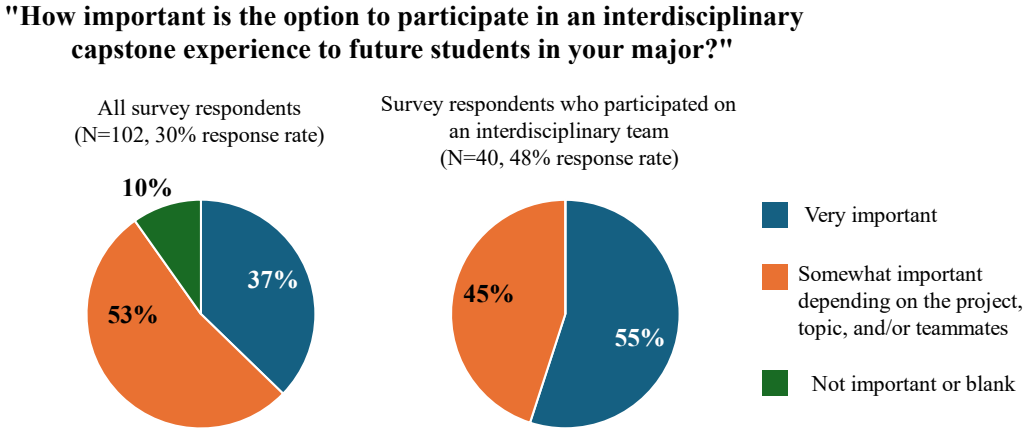

Figure 5: Student feedback on importance of interdisciplinary capstone experiences 2022-2024

Below are select comments on the most valuable aspect of the interdisciplinary experience from students who participated in an interdisciplinary team:

> *"It allowed us to combine aspects from both mechanical engineering and electrical engineering and allowed two different approaches to problems that arose. It also allowed us to tackle solutions from different angles and teach each other information that we might not have learned on our own." (ME student who worked with electrical engineers)*

> *"…Working in an interdisciplinary team helped create a more inspired project that was more interesting rather than a standard building that exists everywhere. It allowed us to speak about an issue and to provide an actual innovative solution." (CE student who worked with mechanical engineers)*

> *"…all critical problems in our world are interdisciplinary by nature. Having this experience in the capstone project allowed (forced?) my team to think about our design challenge from multiple perspectives, and importantly, from multiple scales. It also was an opportunity to learn how to express the design objectives, approach, and constraints to teammates and advisers less versed in my field." (ME student who worked with civil engineers)*

> *"Interdisciplinary projects in senior design has been my most asked about question from recruiters and interviewers. It needs to be encouraged." (CE student who worked with mechanical engineers)*

Many other students commented on the value of gaining different perspectives and expertise by interacting with students and advisors from other majors and being able to accomplish more with interdisciplinary teammates which better prepares students for the real world.

Of survey respondents who did not directly participate on an interdisciplinary team but attended interdisciplinary workshops or class sessions (N=33), 45% still indicated that they benefited from the interdisciplinary class sessions. Survey comments on the most valuable aspects of the interdisciplinary senior design experience from students who did not work on an interdisciplinary team but attended interdisciplinary workshops or social events include:

> *"I liked seeing how the different majors contribute to their projects, and how they are able to fill in the gaps in each other's knowledge. I think it's important to allow student to choose interdisciplinary teams for capstone, as this opportunity isn't really provided elsewhere in the curriculum after freshman year" (ME student)*

> *"The most valuable aspect of the interdisciplinary senior capstone experience is how it mirrors the complexity of real-world work environments, where projects often require input from multiple fields. Collaborating with peers from diverse academic backgrounds also deepened one's understanding and allowed one to approach problems from various perspectives, making the project more innovative and comprehensive." (EE student)*

One comment highlighted how hosting interdisciplinary class sessions and social events fostered a sense of community.

> *"A sense of community with the interdisciplinary experience was the best part. Ice cream socials with fellow seniors make me 1) feel like part of a greater community that I ACTUALLY want to contribute to 2) see what everyone else is doing in a less formal setting 3) actually fun / not boring"*

We were able to provide this valuable interdisciplinary capstone experience to students without eliminating or fully restructuring departmental courses. Even students not directly involved with an interdisciplinary project experience some benefits.

Outcomes Assessment

Selected mechanical engineering student outcomes assessments, correlated with ABET student outcomes were compared for students on interdisciplinary and non-interdisciplinary teams before and after the initiative. These outcomes were assessed by faculty using a rubric-based assessment of the final professional paper and design deliverables.

Table 2 presents the percentages of mechanical engineering students, both on interdisciplinary teams and not, who attained the minimum satisfactory level (75% according to a scoring rubric) for ABET Outcomes (1), (2), (3), and (7). Considering only students on interdisciplinary teams, the percentage of students at or above the threshold of satisfactory attainment meets or exceeds the target of 80% for ABET Outcomes (1), (2), (3) and (7). The percentage of students attaining satisfactory technical writing (ABET (3)) among students on interdisciplinary teams increased after the initiative. Small class sizes and other confounding factors, including lower results overall from the 2021-2022 school year due to returning to campus after over a year of remote instruction during COVID, make it difficult to draw further conclusions from the results.

Table 2. 2021-2024 ME Senior Design Student Outcomes Assessment Comparing Interdisciplinary and Non-Interdisciplinary Teams before and after initiative implementation

			% Outcome Attainment			
		Number of ME Students	Problem Formulation & Solving ABET 1	Engineering Design ABET 2	Technical Writing ABET 3	Self-directed Learning ABET 7
Before Initiative (2021-22, 2022-23)	Interdisciplinary Teams	10	100%	90%	80%	100%
	Non-interdisciplinary Teams	29	76%	59%	72%	93%
After Initiative (2022-23, 2023-24)	Interdisciplinary Teams	21	95%	81%	95%	100%
	Non-interdisciplinary Teams	46	89%	85%	74%	98%

Teamwork Assessment

The Comprehensive Assessment of Team Member Effectiveness (CATME) system of web-based tools was used to formalize and streamline peer evaluations and assess teamwork in all teams involving ME students (including interdisciplinary and non-interdisciplinary teams) [11]. Students demonstrate effective teamwork via an Adjustment Factor (AF) score on the surveys. This score takes into consideration five CATME dimensions: C = "Contributing to the Team's Work"; I = "Interacting with Teammates"; K = "Keeping the Team on Track"; E = "Expecting Quality"; H = "Having Relevant Knowledge, Skills, and Abilities (KSAs)." The CATME method has been used in other courses at The Cooper Union [12]. More detail on CATME's methods can be found in [11], [13], [14] and in references therein.

During the 2023–2024 Capstone cycle, there were 15 Capstone teams that had at least one mechanical engineering student. Of these 15 teams, four of them were interdisciplinary teams having students from both mechanical engineering and other majors for the duration of both semesters. Table 3 disaggregates the interdisciplinary vs non-interdisciplinary teams, indicating the number of teams that have members who have all demonstrated effective teamwork, as indicated by an AF score at or above 0.9. 100% of the interdisciplinary teams demonstrated effective teamwork, when compared to only 63% of non-interdisciplinary teams. The data (not presented here) can be further disaggregated on a student-by-student basis. Of students on the interdisciplinary teams, 100% of the individual team members demonstrated effective teamwork. Looking at the students that were not on an interdisciplinary team, 88% of them demonstrated effective teamwork.

Table 3. Number of teams in which all members demonstrated effective teamwork

	Fall 2023 – November Survey	Spring 2024 – May Survey
Interdisciplinary	4 out of 4	4 out of 4
Non-Interdisciplinary	11 out of 11	7 out of 11

Future Improvements

Although this initiative has certainly improved the participation and support of interdisciplinary projects, there is work remaining to further improve the student experience. In the end-of-year surveys, when asked to comment on aspects of the interdisciplinary capstone experience that could be improved, comments focused primarily on improving communication, coordination, expectations and alignment of the schedule, deliverables, and workload. After the first pilot year, the position of Interdisciplinary Capstone Faculty Coordinator was created to support the additional work of coordinating the interdisciplinary senior projects across departments and organizing the Interdisciplinary Capstone Showcase event and website.

Another area of improvement is in the use of class time, both departmental and interdisciplinary. Currently, each department uses their class time differently (lectures, presentations, workshops, advising meetings, working meetings, etc.) and only meet for the one interdisciplinary hour. This leads to students in different majors having different experiences, regardless of interdisciplinary participation. In the surveys, more than one student wished there was more class time dedicated

to working together or having a separate class section dedicated to interdisciplinary projects, as team members in one discipline often have a working meeting while others are required to attend a workshop or presentation. This also leads to advising feeling different between departments, another comment that appeared in the surveys.

More than a few comments focused on a desire to expand interdisciplinary projects beyond the School of Engineering to other schools and majors or to loosen the requirements of the more structured nature of the CE and ChE senior projects so that their participation in interdisciplinary projects is more readily feasible and encouraged. Nevertheless, the authors of this paper recognize the inherent challenge of ensuring discipline-specific outcomes are being met while at the same time encouraging interdisciplinary projects, but these efforts suggest interdisciplinary approaches within a traditional framework are one means of attaining these simultaneous goals.

Conclusions

The initiative presented in this work proposes an approach to implementing interdisciplinary capstone projects within the framework of existing traditional discipline-specific capstone courses. Individual departments can retain their structures and assessment methods while encouraging interdisciplinarity among the students. This has been implemented at Cooper Union by aligning course meeting times, creating a dedicated time for interdisciplinary advising, presentations, and workshops, and by aligning the expectations and timing of major deliverables. Assessment is still left to individual departments with input and consultation from other departments, not requiring a significant change in any department's curriculum. Additionally, all disciplines come together for team formation, social events, and a final Interdisciplinary Capstone Showcase. Although future work remains for improving coordination of deliverables and assessments between departments and expanding the initiative, course surveys and outcomes evaluation demonstrated that interdisciplinary projects facilitated in this manner are beneficial to students.

This approach to implementing collaborative capstone projects presents an incremental option for schools looking to encourage interdisciplinary projects without creating a new course. By finding a common meeting time and being open to collaboration between instructors, requirements and deadlines can be aligned between departments with minimal changes to existing courses. An effective initiative requires instructor and student buy-in, as well as continuous communication; in return, students gain meaningful experience collaborating across disciplines, enhancing their learning and better preparing them for careers of the future.

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References

[1] L. H. Jamieson and J. R. Lohmann, "Innovation with Impact: Creating a Culture for Scholarly and Systematic Innovation in Engineering Education," American Society for Engineering Education, Jun. 2012.

[2] A. Van Den Beemt *et al.*, "Interdisciplinary engineering education: A review of vision, teaching, and support," *J. Eng. Educ.*, vol. 109, no. 3, pp. 508–555, Jul. 2020, doi: 10.1002/jee.20347.

[3] L. R. Lattuca, L. J. Voigt, and K. Q. Fath, "Does Interdisciplinarity Promote Learning? Theoretical Support and Researchable Questions," *Rev. High. Educ.*, vol. 28, no. 1, pp. 23–48, Sep. 2004, doi: 10.1353/rhe.2004.0028.

[4] I. Kumi *et al.*, "The Benefits of Interdisciplinary Learning Opportunities for Undergraduate Mechanical Engineering Students," in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 48086. doi: 10.18260/1-2--48086.

[5] G. Hunt, "Board 98 : A Case Study of Interdisciplinary Capstone Engineering Design," in *2018 ASEE Annual Conference & Exposition Proceedings*, Salt Lake City, Utah: ASEE Conferences, Jun. 2018, p. 30149. doi: 10.18260/1-2--30149.

[6] J. Walker, G. Howe, and M. Plett, "Interdisciplinary engineering capstone course sequence designed for career preparation," in *2022 ASEE Zone IV Conference Proceedings*, Vancouver: ASEE Conferences, May 2022, p. 44745. doi: 10.18260/1-2--44745.

[7] C. Dolan and O. Plumb, "Interdisciplinary Capstone Design Program A Case Study," in *2008 Annual Conference & Exposition Proceedings*, Pittsburgh, Pennsylvania: ASEE Conferences, Jun. 2008, p. 13.786.1-13.786.12. doi: 10.18260/1-2--3315.

[8] B. Goldschneider and N. Pitterson, "Interdisciplinary Collaboration in Capstone Courses," in *2019 ASEE Annual Conference & Exposition Proceedings*, Tampa, Florida: ASEE Conferences, Jun. 2019, p. 31912. doi: 10.18260/1-2--31912.

[9] K. Olsen, T. Beyreuther, M. Wolcott, and T. Laninga, "Interdisciplinary Design Course Structure: Lessons for Engineering Instructors from a Capstone Design Course," in *2015 ASEE Annual Conference and Exposition Proceedings*, Seattle, Washington: ASEE Conferences, Jun. 2015, p. 26.1011.1-26.1011.12. doi: 10.18260/p.24348.

[10] "2024-2025 Criteria for Accrediting Engineering Programs," ABET Engineering Accreditation Commission, 2023. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2024-2025/

[11] "Comprehensive Assessment of Team Member Effectiveness (CATME)," CATME. Accessed: Jan. 14, 2025. [Online]. Available: www.catme.org

[12] K. Wright *et al.*, "A Case Study of Collaborative Teaching and Learning in Engineering Experimentation: the Hydrostatic Vacuum Tube," in *Volume 7: Engineering Education*, Columbus, Ohio, USA: American Society of Mechanical Engineers, Oct. 2022, p. V007T09A027. doi: 10.1115/IMECE2022-97069.

[13] M. L. Loughry, M. W. Ohland, and D. DeWayne Moore, "Development of a Theory-Based Assessment of Team Member Effectiveness," *Educ. Psychol. Meas.*, vol. 67, no. 3, pp. 505–524, Jun. 2007, doi: 10.1177/0013164406292085.

[14] M. W. Ohland *et al.*, "The Comprehensive Assessment of Team Member Effectiveness: Development of a Behaviorally Anchored Rating Scale for Self- and Peer Evaluation," *Acad. Manag. Learn. Educ.*, vol. 11, no. 4, pp. 609–630, Dec. 2012, doi: 10.5465/amle.2010.0177.