Widening the Umbrella in the Midst of a Pandemic: Mathematics, Statistics, and Computer Science Students Join First Year Engineering Design Course

Abstract

Background: Prior to emergency remote instruction in Spring 2020, the UVM College of Engineering and Mathematical Sciences (CEMS) began a significant realignment of undergraduate curricula across its Engineering (Mechanical, Civil, Environmental, Biomedical, Electrical), Mathematics, Statistics, and Computer Science programs. An early outcome of this transition was the redesign a first-year seminar course (1 cr.), previously only available to students in engineering. The proposed course (CEMS-050) would be required for all incoming first-time, first-year students (~300) and would create opportunities for students to practice key skills common to the CEMS disciplines, including technical communication, teamwork, and problem-solving. In addition, the course would introduce students to each of the College's ten academic programs, campus resources, advising, and provide opportunities for cohort-building during a semester when most general education courses occur in other colleges. In Spring 2020, feedback was gathered via department-led discussions and a multi-disciplinary working group was formed to develop the course learning objectives and assessment strategies for implementation in Fall 2020.

Course Structure: Learning outcomes focused on the Design-Thinking process, effective and inclusive teamwork, technical communication, self-reflection and bias, and the ability to leverage campus resources. A project-based structure was adopted to incorporate these learning outcomes into two projects: (1) "Micro-Design Projects", to practice teamwork and design while building simple mechanisms and structures (floating table, mechanical hand, water-balloon launcher), (2) "Semester-long Projects", in which students address a campus-based problem, posed by a partnering campus organization (Facilities, Waste, Transportation, Health and Wellness). In both cases, students voted on their desired project and were placed into interdisciplinary teams. Semester project options spanned three themes (Energy, Resources, Health) and seven specific challenges. Students presented their proposed solutions to the campus community at a final virtual poster event in December 2020.

COVID-Specific Challenges: In Fall 2020, students chose whether to attend courses entirely from home or remain on campus for in-person and hybrid courses. CEMS-050 held in-person labs, which required additional space, PPE, disinfection protocols, and specialized classroom technology to engage at-home students. Micro-Design kits were sent to at-home students and additional instruction was provided to support teamwork in mixed-modality teams. UVM's infection rate remained low during this period (0.07%) due in part to strict testing and quarantine requirements.

Lessons Learned: Overall, students across disciplines responded positively to the opportunity to engage with peers and campus partners while working on meaningful real-world problems. Student feedback indicated a strong positive impact of in-person instruction (most other courses were entirely remote). At-home students expressed some difficulty working in mixed-modality teams and many teams struggled to manage team productivity regardless of modality. Further improvements include streamlining project-planning assignments and strengthening the peer-

and self-reflection components of the course. In fall 2021, we will consider the role of sense of belonging in the academic trajectory and retention of first year students.

1. Introduction

First year experience courses for undergraduate students have long been associated with improved retention and graduation rates in engineering and STEM fields [1] – [3]. Although several examples exist in specific engineering disciplines and combinations of engineering disciplines [4], [5], [6], there are relatively few examples of first year, project-based courses that integrate engineering, mathematics, statistics, and computer science majors [7]. This work-in-progress paper describes a multi-disciplinary first year seminar that was developed in 2019-2020 at the University of Vermont, College of Engineering and Mathematical Sciences, and first taught in Fall 2020 in the midst of the COVID-19 pandemic. The course development process, structure, and adaptation to COVID-19, as well as observations and improvements following the first offering of the course are described.

2. Background

The College of Engineering and Mathematical Sciences (CEMS) at UVM provides undergraduate and graduate programs in engineering, computer science, mathematics, statistics, data science, and complex systems. ABET accredited Bachelor of Science degrees in engineering include Civil Engineering, Environmental Engineering, Biomedical Engineering, Mechanical Engineering, and Electrical Engineering. Engineering B.S. and Engineering Management B.S. degrees are also offered. Additionally, the college offers degrees in Computer Science, Computer Science and Information Systems, Data Science, Mathematics, and Statistics. College-wide enrollment has ranged from 987 to 1500 students since 2011 with individual program enrollment ranging from 47 to 330 in 2020 [8].

In Spring 2019, the College finalized the 2019 Strategic Plan with input from faculty, staff, and students. A key goal of the resulting strategic agenda was to "transform undergraduate education", including the expansion of active and project-based learning, the development of a core curriculum for all undergraduate programs, and more support for faculty professional development focused on teaching and learning. In Fall 2019, the College began a two-year process to define new college-wide curricular goals and learning outcomes that would be shared across undergraduate programs.

The new CEMS Core Curriculum was designed in two stages. The first stage (Fall 2019) included the establishment of minimum credit hours in the following areas: 20 credits of Mathematics including at least one Statistics course; 3 credits of computer programming; 3 credits of Humanities; 3 credits of Social Sciences; 3 credits of Integrative Culminating Experience (e.g., Capstone). In addition, students in all undergraduate degree programs would need to complete a one credit first semester, first year seminar course, ultimately named CEMS-050 First Year Seminar. Although engineering programs already required first year seminar and capstone courses prior to 2019, Computer Science B.S., Computer Science and Information Systems B.S., Statistics B.S., Data Science B.S., and Mathematics B.S. did not.

The second stage (Spring 2020 – Fall 2020) of the Core Curriculum development included the identification of core competencies and associated learning outcomes that would be shared across CEMS undergraduate programs as well as the identification and/or development of courses in each program that would incorporate these learning outcomes. The proposed first year seminar would include foundational learning outcomes in each of the core competency areas: Teamwork & Leadership, Communication, Ethics in the Profession, and Data Dexterity.

3. Course Development Process

The CEMS-050 First Year Seminar course development began in Fall 2019 and continued through Summer 2020 with the goal of offering the course for the first time in Fall 2020. The initial framework for the course was inspired by (1) an existing first year seminar for engineering students, (2) input from an interdisciplinary cohort of faculty that attended the Project Based Learning workshop at Worcester Polytechnic Institute in 2019 (Worcester, MA), and (3) input gathered from faculty during department meetings in Spring 2020.

3.1. First Year Engineering Seminar

Prior to Fall 2020, a first year seminar in engineering provided opportunities for students to learn about (1) various fields and employment opportunities in engineering, (2) the engineering design process, (3) campus and advising resources, (4) professionalism in engineering, and (5) accountability and decision-making in college. Students were required to attend one lecture (75 min) and one lab session (50 min) each week and were assessed based on attendance (20%), assignments (40%), and a final poster presentation of a course project (40%). Course projects required student teams to propose a solution to an engineering problem. Specific engineering problems were initially identified by student teams and project work typically occurred during lab periods or outside of class.

3.2 Input from Project-Based-Learning Faculty Cohort

Five faculty from Civil and Environmental Engineering, Mechanical Engineering, Computer Science, Mathematics, and Statistics attended the Worcester Polytechnical Institute workshop on Project Based Learning in June 2019 [9]. In this institute, faculty learned the benefits of project-based approaches and strategies for developing and scaffolding interdisciplinary projects. This faculty cohort drafted the first syllabus and outcomes for the course, which was submitted during the first phase of curriculum development and later refined with input from departments and a summer 2020 faculty working group.

3.3 Input from Departments

Departments were asked to provide input to the course development process in Spring 2020 by considering the following questions: (1) What are the most important skills or experiences you would want first year students in your program to gain in this course? (2) What types of problems (e.g., local, global, discipline-specific) would you like first year students in your program to address in this course?

Common themes identified for question one included data and information literacy, teamwork and collaboration, ability to communicate effectively with a range of audiences, issues of professional ethics and bias, and opportunities to interact with faculty, staff, and peers. Engineering programs also indicated the design process and prototyping as important areas for consideration. Project topics for question 2 were primarily focused on sustainability issues including renewable energy, clean water, resource recovery, waste streams, as well as health and human disease and projects using pre-existing campus data. Program input on these questions influenced the final definition of student learning outcomes and project themes.

3.4 Summer 2020 Working Groups

In order to finalize the course learning outcomes, assessment methods, and projects, a group of eight faculty met for two days of remote meetings in June 2020 and then continued to work asynchronously throughout the summer. The working group included faculty from the WPI cohort and a few others, including the faculty member that would serve as primary instructor for the course in Fall 2020. In addition to finalizing learning outcomes, the group developed the concept of MicroDesign projects as a preliminary three-week intensive introduction to the five stages of the Design Thinking Process, central themes and guidelines for a semester-long, campus-based project, specific lab activities, and additional resources from each disciplinary area to support students during project work.

4. Course Design

Several elements of the original engineering seminar were incorporated into the CEMS 050 First Year Seminar, including learning outcomes associated with the design process, professionalism, understanding of the various CEMS disciplines, and information on campus and advising resources. However, the inclusion of students in non-engineering majors necessitated a shift away from engineering-centric examples, projects, and frameworks for understanding the design process, many of which were sourced from departments or faculty in the course development working group.

4.1 Campus-Based Projects

The campus-based project is central to the course and serves as an anchor for multiple learning outcomes. Student autonomy and engagement is encouraged by providing students several pre-defined project topics (challenges) to choose from. Additionally, projects are based on current and real problems facing the campus community and associated with specific departments or organizations on campus, introduced to students as 'Project Partners' (e.g., Custodial Services, Transportation and Parking Services). This allows students to not only exercise choice, but requires them to go out into the campus community and interact with people and processes that they might not otherwise gain exposure to. Project challenges are categorized by one of three themes: Resources@UVM, Energy@UVM, Health@UVM, as inspired by the National Academies of Engineering Grand Challenges themes [10]. In Fall 2020, students were introduced to the Project Partners and project challenges in the second week of classes and provided a one-page description of each challenge on which to base their decision (See example in Supplemental Information 9.1). Examples of Fall 2020 challenges included the "Davis Center Water Efficiency Challenge", in which students were asked to design a greywater collection system for the student center roof to replace potable water in toilets, and "Staying Connected and Active During a Pandemic", in which students were to design new features for a campus wellness app that encourages healthy habits and connection for students during the COVID-19 pandemic. Supporting information such as relevant data from Project Partners and related studies or examples were also provided for each project as a starting point for student research.

4.2 Learning Outcomes and Assessment

A total of six learning outcomes were defined for the college-wide first year seminar (Table 1). Assessment methods included weekly homework assignments, lab activities, and a final poster presentation. Weekly homework assignments were designed to scaffold the campus-based projects such that students were always working directly on a component of their project that they would ultimately present during the final poster session. Project-related assignments primarily addressed learning outcomes 1-5. Learning outcome 6, which focused on student success strategies, was assessed primarily through auxiliary assignments (Table 1). Due to it being a one-credit course, lab sessions were regularly used as time for students to work on project-related and team assignments. This helped to minimize the time needed for coursework outside of lecture and lab. Additionally, incorporating assignment work into lab time meant that student teams always had a common time to meet and work on their project together and that teams received sufficient instructional support. Final grades were determined based on four areas: Participation (15%), Teamwork (25%), Assignments (45%), and Final Project Presentation (15%).

Table 1. Learning outcomes and assessment methods for CEMS 050 First Year Seminar.

#	Learning Outcome	Assessment Method
1	(Design) Apply the core elements of the design thinking process and propose a solution to a campus-based problem	Week 3: Design Thinking Flipgrid Post Week 3 – 5: MicroDesign Project Week 6 – 14: Campus-Based Project Assignments Week 15: Final Poster Presentation
2	(Teamwork) Practice the key components of effective and inclusive team work including self-awareness, reflection, communication, and goal setting	Week 2: Paper Airplane Activity Week 3 – 5: MicroDesign Project Week 6: Team Contract for campus-based project Week 8: Project Planning Gantt Week 11: Peer-Team Evaluation Form Week 15: Final Poster Presentation
3	(Communication) Effectively communicate the technical aspects of your project to an audience of instructors, mentors, peers, and project partners	Week 5: Project Research & Bibliography Week 7: Problem Statement Week 8: Project Planning Gantt Week 12: Poster Presentation File Week 14: Poster Presentation Practice Week 15: Final Poster Presentation
4	(Ethics) Reflect on ethical and/ or societal issues as related to your semester project or field of study	Week 12: Poster Presentation File (required poster section: Potential Impacts) Week 14: Inclusion and Bias in STEM reflection activity
5	(Research) Gather and evaluate relevant and reliable information and data from a variety of sources	Week 5: Project Research & Bibliography Week 7: Problem Statement Week 15: Final Poster Presentation

6	(Student Success) Demonstrate key skills necessary for success in college and beyond	Week 1: Academic Planner Week 1: Self-Reflection Activity Week 5: Project Research & Bibliography (completed using campus library resources) Week 9: Draft Schedule for Spring Registration Week 15: End-of-Semester Critical Reflection

4.2.1 Design Outcome

Instruction for Learning Outcome #1 focuses on the Design Thinking Process, as a widely applicable and user-oriented approach, rather than the engineering design process. The Design Thinking Process is introduced to students in the first week of the course and each individual stage (Empathize, Define, Ideate, Prototype, Test) is subsequently covered and reinforced through weekly assignments (Table 1). Prior to commencing the semester projects, student teams work for three consecutive lab periods on a MicroDesign Project. Students are given a choice of three MicroDesign Projects, which are introduced as a letter from the user (See example in Supplemental Information 9.2), and guided through each stage of the Design Thinking Process in a series of lab activities and a final reflection assignment. This first application of the design process in the form of MicroDesign projects provides a fast-paced and low-stakes introduction to the stages that students will work through for the remainder of the course in order to complete the larger campus-based project. Although the project options are playful (e.g., floating table, water balloon slinger) and the materials crude (cardboard, popsicle sticks, balsa wood, etc), students are encouraged to focus on understanding the design process and cultivating a constructive team dynamic, rather than on the simplicity of the problems they are asked to solve.

4.2.2. Teamwork Outcome

Instruction for Learning Outcome #1 focused on the importance of teamwork during and beyond college, elements of effective and inclusive teamwork, and constructive and destructive team behaviors. Teamwork was first introduced in the second week of lab during a team-based paper airplane building activity. Students were assigned to teams of four. Team members take turns making decisions about each individual fold of the airplane. Each team member must abide by the decision of the student whose turn it is to choose a fold or respectfully debate that student until consensus is reached. Teams are limited to eight folds (two rounds), resulting in four nearly identical paper airplanes. Teams test their paper planes and complete three distance measurement per plane in order to generate a total of twelve replicate measures of their design. Class-wide data is compiled and used in a later lesson on basic statistical methods and use of Microsoft Excel. Additional opportunities for students to practice teamwork occur during the MicroDesign Project (See 4.2.1) and the semester campus-based project.

4.2.3. Communication Outcome

Instruction for Learning Outcome #3 provides an overview of what technical communication is and how it is commonly represented in different disciplinary fields (Table 1). Students work on different aspects of technical communication throughout the course including research methods and citation strategies (week 5), drafting problem statements (weeks 3 and 7), abstract writing (week 9), poster design (week 12), presentation practice (week 14) and the final poster presentation (week 15). In Fall 2020, an undergraduate writing center tutor visited the lecture in week 5 to discuss plagiarism and the importance of citation strategies in writing as well as ways of accessing the tutoring center and library resources. Upper-class undergraduate students were also invited to visit the lecture, demonstrate their poster presentations, and provide tips for preparing and presenting. The final poster session provided an opportunity for teams to present their work to instructors, faculty reviewers, other students, and peer mentors affiliated with the course (See 4.3 Instructional Support).

4.2.4. Ethics Outcome

Instruction for Learning Outcome #4 centers on ethical issues common to each CEMS discipline and issues of bias and inclusion in STEM. Due to a shortened semester schedule in Fall 2020, instruction on ethical issues was limited, save for the issues introduced during the 'Program Visits' in which faculty representatives from each program attended the lecture to provide more insight into their field, opportunities for student engagement, and employment after college. One lecture was dedicated to issues of inclusion and bias in the STEM disciplines, though this activity did not contribute to students' grade. Students were required to include a "Potential Impacts" section in their final poster presentation, describing any potentially positive or negative impacts of their proposed solution, should it be adopted by the Project Partner, and considering ethical, cultural, societal, and environmental impacts.

4.2.5. Research Outcome

Instruction for Learning Outcome #5 centers on tools for conducting project research. Students are first introduced to campus library resources in week 5 during a visit from a research librarian and overview of methods for finding sources related to their projects (e.g., research databases, search functions, inter-library loan, "Ask a Librarian" program). Students must immediately put this information to use in the assignment for week 5: Project Research & Bibliography. Soon after the project teams are assembled, students are provided time during the lab session to compile the individual research they did for this assignment and identify additional information or data needs. In week 7, teams draft the problem statement for the project, which is guided in part by the research they have completed on their topic. Teams are also expected to provide a brief summary of their research in the Background section of their poster presentation.

4.2.6. Student Success Outcome

Instruction for Learning Outcome #6 occurs throughout the semester and in parallel to the other more integrated themes of the course (i.e., learning outcomes 1-5). The goal of this outcome is for students to develop the skills necessary to be successful in college. Assessment of this outcome occurs through individual assignments and self-reflection activities. This outcome centers on approaches that encourage students to develop as self-directed and self-reflective learners [11], such as reflecting on personal definitions of success, short and long-term goal planning, regular assessment of goals, time-management, giving and receiving constructive feedback, preparing for course registration, utilizing campus resources, and asking for help.

4.3 Instructional Support

In Fall 2020, course planning and instruction was led by a single faculty member with additional support from other faculty for lab instruction. With the general structure established, yearly preparation for the course centers on project development (i.e., Project Partners, challenges, and supporting materials), coordinating the many visitors that share information on program requirements, library and writing center resources, student services, career readiness, study abroad, student clubs, and student research opportunities, among others, and coordinating undergraduate peer mentors.

The peer mentor program in CEMS recruits 25-35 undergraduate students in their 2nd, 3rd, or 4th year to provide instructional and mentoring support to CEMS 050 students. Originally an 'Engineering Peer Mentor' program, the program was adapted in 2020 to support the new college-wide first year seminar. Students are recruited each spring and trained in mentoring and student support methods, campus resources, and instructional facilitation prior to the fall semester.

5. COVID-19 Adaptations

The University of Vermont remained open and provided four distinct modalities of instruction in Fall 2020: In person, remote synchronous, mixed (in person / remote synchronous), and online [12]. As was the case for many universities, remote and mixed synchronous modalities had not been offered prior to remote emergency instruction in Spring 2020 and the Fall 2020 semester was the first term in which these modalities were formalized at the University. Online courses continued as usual and in person courses were scheduled in classrooms large enough to ensure six-foot distancing for students and instructors. On campus employees and students were required to wear a face mask at all times and on-campus students were required to complete weekly COVID-19 testing. Additionally, students were given the choice to attend classes on-campus or attend remotely for the entire semester under the 'at-home' designation. In Fall 2020, 298 first-time-first-year students enrolled in the course, of which thirty were considered at-home students.

University requirements for modality, physical distancing, and at-home policies created several unique challenges for the CEMS 050 course. Concerning modality, lectures were taught synchronous remote and labs were taught as mixed sections with some students attending lab in person and some connecting remotely from home. MS Teams was used for remote components of both the lectures and labs. During lecture, chat and polling features were used heavily to gather student questions and deploy formative assessments, respectively. Lecture recordings and slides were made available to students after each session. The University also set up a dedicated MS Team for each course, which students and instructors could access for class meetings, communication, collaborative document editing and sharing of course materials. This was in addition to the primary LMS, Blackboard (Blackboard Inc., 2020), which did not have these capabilities at the time. Because the labs were designed to accommodate both in person and remote students, a significant amount of flexibility was also provided to on-campus students unable to attend lab in person due to minor illness or other circumstances that made it challenging for them to attend.

At-home and remote students would enter the remote meeting at the beginning of each lab session to watch the lab briefing for that day. Since all lab activities involved a group activity, at-home and remote students would then join a remote meeting with their assigned teammates in a pre-defined channel set up by the instructor. Dedicated team channels were set up for the MicroDesign and campus-based projects where students could meet during or after lab sessions, share and edit documents, and submit team homework assignments. Additional instruction and preparation was necessary to ensure that at-home students felt included during the remote lectures and lab periods. For example, each lab activity included a section specifically written for at-home students if modification was needed and in person students were regularly reminded to make sure to include their at-home teammates in any conversations or decisions made during lab. For the MicroDesign projects, which included one lab dedicated to prototyping with basic materials, at-home students were sent MicroDesign Kits containing the necessary materials and instructions so that they could participate in the prototyping and testing stages alongside their in-person teammates.

To ensure physical distancing, lab seating was adjusted such that 35-40 in person students in each section could be seated safely in groups of four. This required an additional, adjacent room to be used. The lab safety briefing for the course was designed to include COVID-19 guidelines, among other safety requirements, which students were tested on prior to the first in person lab. Students were also required to sanitize their work surface before leaving class and wear nitrile gloves when sharing materials and tools.

The greatest challenge of COVID-19 in Fall 2020 was maintaining student engagement. In a Spring 2020 survey to CEMS students, students expressed difficulty remaining engaged, particularly in remote courses, though some students expressed preference for the modality due to the increased flexibility it offered. As a result, CEMS 050 was intentionally designed to increase opportunities for engagement and student interaction, particularly in the remote lectures. Lectures were structured to deliver new information in shorter ‘chunks’ (approx. 15-20 minutes) followed by a short activity or poll. Activities in the remote lecture often included a brief video or lecture followed by group work in breakout channels. When structured this way, student engagement in polls and group activities was consistently higher than when students listened passively, though this was not formally quantified.

Finally, the final poster presentation session could not be offered in person as a result of University and state-wide restrictions on in-person meetings and events. Therefore, a remote poster session was organized using MS Teams and a dedicated webpage was developed to share information on the course and projects as well as to access team posters and links to team presentations [13]. Faculty, students, project partners, and peer mentors were invited to ‘drop-in’ to the team meetings during one of two one-hour presentation sessions. Although more than 25 peer mentors and 15 faculty were recruited to attend the remote sessions, some student teams reported being left in silence for long periods of time. Teams were encouraged to rotate one member out at a time so that they could visit other student teams during the session, as one would in an in person event, but this did not seem to be common practice. Although in person poster sessions are planned for future years, a more interactive meeting tool or webpage design should be considered if a remote event is needed in the future.

6. Observations and Improvements

Although COVID-19 necessitated the adoption of new classroom technology and teaching strategies, many of the tools and strategies used in Fall 2020 have benefits beyond pandemic teaching. For example, class recordings provide flexibility to students that cannot attend synchronously and allow students to back-track and re-watch certain portions of a lecture, which may improve learning. Collaborative document editing was needed for in person and at-home students to interact on several class activities and assignments, but could be used to cultivate a positive team writing practice irrespective of learning modality. Finally, the private channels that were setup for each project team on MS Teams streamlined the sharing and submission of team assignments and could be used regardless of modality.

An end of semester reflection survey was given to students in December 2020. Two-hundred and forty-four out of nearly three-hundred students responded. The survey asked students to rate their understanding of the course learning outcomes, their sense of preparedness for continuing study in the College, the quality of their team's proposed solution and final presentation, and their favorite and least favorite parts of the course.

Students rated their understanding of outcomes #1 - #5 in the following order (% of students that ranked their understanding of the outcome most highly): Design (#1: 57%), Teamwork (#2: 46%), Ethics (#4: 46%), Communication (#3: 40%), Research (#5: 26%).

Table 2. Number and percentage of students that ranked understanding of learning outcomes (Response rate: 244 out of 293; 83%).

Question	Rank 1 Response: *"A lot"*	Rank 2 Response: *"A little"*	Rank 3 Response *"Not very much"*
#1: How much would you say you learned about the design process this semester?	140 (57%)	84 (34%)	20 (8%)
#2: How much would you say you learned about working effectively in a team this semester?	113 (46%)	111 (46%)	20 (8%)
#3: How much would you say you learned about technical communication and presentation this semester?	97 (40%)	124 (51%)	23 (9%)
#4: How much would you say you learned about the potential impacts of your project this semester (environmental, cultural, ethical)?	113 (46%)	104 (43%)	27 (11%)
#5: How much would you say you learned about gathering credible sources of information and data this semester?	63 (26%)	133 (54%)	48 (20%)

Given the significant amount of class time and number of assignments allocated to outcomes 1 and 2, this result is not surprising. However, the relatively low ratings of outcomes 3 and 5 is of interest, given the centrality of written/oral communication and research to the course project. It is possible that the relatively limited instruction for the Research outcome (one lecture dedicated to finding credible sources and constructing a bibliography) contributed to this low rating or that the assignment related to research and bibliography development came very early in the semester with limited opportunities for practice or feedback until the final presentation. Future versions of the course should provide greater opportunities for assessment and feedback either through formal assignments or in-class activities (e.g., peer or instructor review sessions of the final poster prior to presentation day). In contrast, the communication outcome (#3) was heavily assessed (e.g., written problem statement, project planning Gantt chart, poster presentation) but only 40% of students ranked this outcome highly. This could be due to the sequencing of lessons and assignments related to communication. Specifically, in Fall 2020, students had completed three communication assignments before being introduced to the concept of technical communication and the specific forms it may take. Improvements to the Communication outcome could include opportunities for students to revise and incorporate instructor feedback more frequently and modification of the sequence of technical communication instruction and assessment. In lieu of a parallel question on the Student Success outcome (#6), students were asked to rate how prepared they felt to continue in the College / at UVM after completing the course. Ratings for this question were 4.39 +/- 0.99 out of five.

Over the course of the semester, faculty visited the lecture to describe the requirements and opportunities for students within their programs. This was the main mechanism by which students in CEMS 050 received new information related to choice of major as well as informal conversations with peer mentors. Twenty-two percent of students (54 students) indicated that the course influenced their plans for college in some way with the majority of reasons being related to choice of major. Of the 54 students that indicated the course influenced their plans for college, 32 students indicated that they were confident in their choice of major after completing the course and 22 indicated that they would be switching to a different major within the college. None indicated that they planned to leave the College or University entirely.

In 2021, the first-time-first-year 1-year retention rate increased to 89.7% from 85.5% in the prior year [14]. While these results are promising and indicate a positive impact of the college-wide first year seminar on student retention, there were likely other local and global factors at play. Importantly, COVID-19 not only impacted how students experienced their first semester in college but their motivations to attend and persist during an economically uncertain period. For example, nation-wide first year retention rates increased by 1.4% on average in public four-year colleges, with greater retention occurring at more affordable schools [15]. Support for teaching and learning also increased in the College during this period as did opportunities to engage with academic support services and other student services on campus. Due to many factors changing during this period, it may be too soon to determine with any certainty the specific impacts of the first year seminar course and other curricular changes on student retention. Further monitoring of student flow patterns and specific program enrollments will be necessary.

When asked to reflect on their favorite parts of the course, students indicated the opportunity to meet with their peers in person during the labs, to learn more about the different programs in the college, and to work in teams on a campus-based project. There were no comments related to the relevance of projects to Mathematics, Statistics, and Computer Science majors. Rather, many students indicated an appreciation of the interdisciplinary nature of projects.

When asked to describe their least favorite parts of the course, many students indicated that some of the projects and assignments were too simplistic whereas others indicated that the work required exceeded what should be expected for a one credit course. These comments are somewhat at odds and indicate that incoming students arrive with a range of abilities and expectations for their coursework as we would expect. Since the main goal of the first year seminar is to provide all students a similar foundation for success in the College, it is likely that there will always be students that excel and those that struggle. This reinforces the need for the course to remain student-centered and for instructors to understand the diverse needs of students so that appropriate support and encouragement can be given. In order to gather more formative feedback from students, pre- and mid-term surveys could be deployed in future years that gather information on student goals, additional support needs, and sense of belonging [16].

In conclusion, the CEMS 050 First Year Seminar course has created an opportunity for students in engineering, computer science, mathematics, statistics and data science to have a shared learning experience in the first semester of college when most other courses occur outside of the College or their major. The course ensures that all students gain the same exposure to campus resources and information on academic programs, and practice key skills (design thinking, teamwork, communication, etc) through an interdisciplinary, project-based experience of their choosing. Future improvements to the course include additional attention to the Ethics and Research outcomes, better sequencing of Communication instruction and assessment, and better assessment of student experience including pre- and mid-term surveys as it relates to personal goals, sense of belonging, and ultimately retention. Given the complexity of this course and the necessary improvements it may also be necessary to consider an increase in credits or simplification of the learning outcomes. This could ensure sufficient there is sufficient 'room' in the course to go into greater depth on the ethics and research outcomes while still honoring the definition of a credit hour.

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9. Supplemental Information

9.1 Example description of a campus-based project option provided to students in Fall 2020 CEMS 050 First Year Seminar:

Food Waste Collection*:* In 2012, the Vermont Legislature unanimously passed the Universal Recycling Law (Act 148), banning three major categories of materials in Vermont trash bins. Among these were food scraps (organics and compostable kitchen wastes). As a large institution, UVM was among the first organizations in the state to be affected by this law. However, prior to this legislation being passed, UVM had been collecting food scraps and compostables for a number of years. UVM Food scraps were originally sent to the Intervale Center but are now sent at Green Mountain Compost. This year, Act 148 extends to all Vermonter's and all facilities at UVM. ***UVM Recycling & Zero Waste (Partner) is seeking solutions that would allow for the efficient and timely collection of food scraps from academic buildings as well as buildings/facilities that are not on Main Campus (See Map) while minimizing reliance on custodial staff.*** Solutions should be evidence-based and focus on informing and influencing student/faculty/staff behavior to dispose of food scraps correctly in the appropriate locations. Solutions may include social incentives that promote the proper disposal of food scraps, knowledge campaigns, or technological and infrastructural solutions (smart bins, campus-wide food waste collection infrastructure, mobile apps).

9.2 Example of MicroDesign project option provided to students in Fall 2020 CEMS 050 First Year Seminar:

Option B – Floating Table

Dear Students,

I am a local furniture maker who is always seeking innovative table designs, which are also strong and functional.

I am interested in using an *anti-gravity suspension structure* to build a 'floating table' for my next project. However, I am not sure of how strong it will be in comparison to a regular table with four legs.

Would you be able to help me prototype and test a floating table design? How much weight can a floating table hold per unit mass of building materials in comparison to a regular table? Which is the strongest design?

Here are a few videos I found of different floating table designs that may be worthy trying, but I'm open to other designs too!

https://www.youtube.com/watch?v=BrDLjiPlH-Y

https://www.youtube.com/watch?v=ZwkCMWrHvyE

Thank you!

Eliza Tablemaker

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Photo: Simplicity GB