2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #51547

Redesign and Implementation of First Year Engineering Design Cornerstone Course

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Complete Evidence Based Practice Paper

Redesign and Implementation of First Year Engineering Design Cornerstone Course

Introduction

In 2005, the National Academy of Sciences recommended implementing first-year engineering courses to "introduce the 'essence' of engineering" early in the curriculum [1]. Engineering colleges have since developed various first-year engineering programming from a common first-year experience with multi-disciplinary projects, to a common first-year experience that spans multiple engineering disciplines with small projects, or to more discipline-specific courses for students with direct matriculation into a specific major. These courses aim to provide an early introduction to the engineering discipline [2] thus positively impacting a student's engineering identity [3], which has been shown to increase student persistence within the engineering field [1]. Supporting students' engagement and confidence in engineering design during their first year is critical to persistence and long-term success in an engineering program [4]. Even in courses that include project-based learning, fragmentation between modules or instructional approaches can limit students' opportunities to connect technical content with design decision-making thus requiring careful course design and implementation.

Background

A previous common engineering course for all first-year engineering students at Villanova University consisted of a half-semester "core" class, in which students learned the engineering design process in a group-based learning environment, followed by a half-semester faculty-developed mini-project that allowed for project-based, hands-on learning. The course structure presented several teaching and learning challenges. The two independent "halves" did not sufficiently complement each other, as they offered different learning objectives taught by different instructors. Lack of consistent instructor presence across the full semester led to difficulties in monitoring student performance, critical in the first college semester, and affected student success and retention in the college. Additionally, because engineering design was only taught in one half of the semester, students lacked sufficient depth of knowledge of the engineering design process evidenced by instructor feedback in subsequent upper-level courses.

The revised course structure is intended to provide greater consistency in learning objectives and instructor exposure to ensure delivery of foundational knowledge and monitoring of learning progress required for student success. This three credit-hour-course is taken in the Fall semester of the first-year with no expected pre-requisite knowledge. A committee comprised of faculty members from each of the departments within the college redesigned and restructured the course focusing on the engineering design process using team-based and project-based learning activities. To ensure the course redesign stayed true to Villanova's unique Augustinian teaching philosophy, the committee did not consult all prior works on redesigning first-year design courses. Instead, the committee relied on a strong foundation in pedagogy and knowledge of engineering education practices.

To begin, the committee identified four course "competencies", blending a need for technical rigor with immersion in the engineering design-thinking protocols. Learning objectives (Appendix A) within the four competency areas were developed using Bloom's revised taxonomy [5], [6] and were mapped, when applicable, to student outcomes from ABET [7].

Components of the competency area “engineering professionalism and social responsibility” align with a university mission to ensure social responsibility discussions were embedded in discipline-specific coursework. The need for empathy in engineering education, specifically as part of technical work rather than a separate discussion, is also noted in the field [8]. The competency area “technical skills” was included to ensure that students were exposed to a core-concept in each engineering discipline offered by the university and to act as a kind of “integrated STEM” model to ensure technical rigor in the course [9].

Course design

A university level grant was secured for the course redevelopment and allowed for (1) building out the instructional activities and assessment tools for the course and (2) providing comprehensive course materials and training for instructors and teaching assistants to ensure high-quality instruction. Because four different sections of the course would be taught by four unique faculty members, it became apparent that a new course coordinator position was required to ensure consistent course content and delivery across multiple sections. This was reinforced with the introduction of additional, smaller sections and more instructors in years after the inaugural offering of the remodeled course.

Remodeled lesson plans including content, assessments, and pedagogy for the course were developed using Wiggins and McTighe’s “Backwards Design” [10]. This led to a course where the engineering design process (Figure 1) was reinforced multiple times through scaffolded and discipline-specific design briefs related to a humanitarian engineering design project and a student selected conceptual design project. Hands-on lesson plans from previous iterations of the course that were successful and popular with students were adapted for the design project [11], [12]. Overlayed throughout the course are lectures on the engineering profession and social responsibility termed broader impact (BI) topics including Sustainability using the Engineering for One Planet framework [13], Social Justice, Universal Design, Humanitarian Engineering, Engineering Professionalism and Licensure, and Risk and Ethics in Engineering. Reflection on the broader impact topics are incorporated in the written design briefs (DB). Using CATME [14], students are assigned to a semester long team for project-based work, whereas, individual assignments and quizzes are used to reinforce required technical and broader impact topics. Effective teamwork is reinforced using a Working Styles Assessment [15] and Tuckman’s Linear Model of Group Development [16], [17]. Teamwork was revisited throughout the semester with three (3) CATME Peer Evaluations [14].

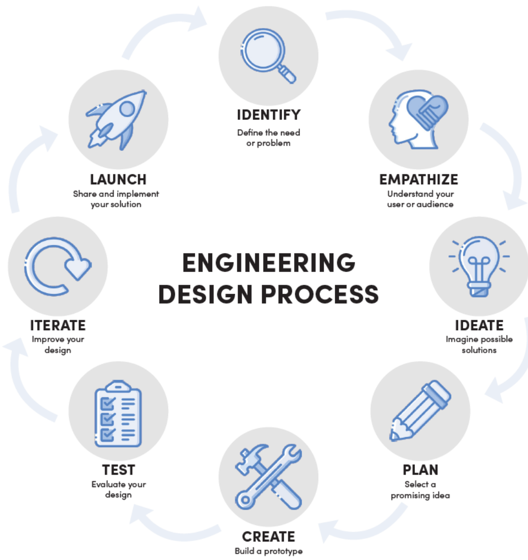


Figure 1. Engineering design process graphic utilized throughout the redesigned course

Humanitarian engineering design project

Students first complete a simulated humanitarian engineering design project to provide access to clean water for the Nina School for the Deaf in Siaya County, Kenya, an actual project from the College's Engineering Service-Learning program. Students begin the project with a video recording of a graduate student, who is from Siaya County and familiar with the Nina School, describing the current school compound and conditions, researching the school's current industry partners, and researching other villages and water projects that have been successful in the region. This information is used wholistically to clearly identify the problem and develop an empathy map, both of which are used to construct the Point of View (POV) statement. Using the POV, students ideate solutions, identify design constraints and criteria, and draft a design brief (DB) with a conceptual solution. The project is then intentionally scaffolded into three technical design briefs: DB1 Water Tank, DB2 Monitoring and Feedback System, and DB3 Support Structure to ensure technical competencies are met and to reinforce a common engineering skill set.

DB1 Water Tank: Engineering concepts of mass balance, conservation of energy in fluid mechanics, and steady state flow are taught using a combination of lectures, in-class laboratories, and guided Excel spreadsheeting. Students utilize these concepts and the generated spreadsheet that calculates and graphs water volume in a tank per hour based on a simplified supply and demand to size a water tank for the community considering water demand, sustainability, and social justice topics (Figure 2).

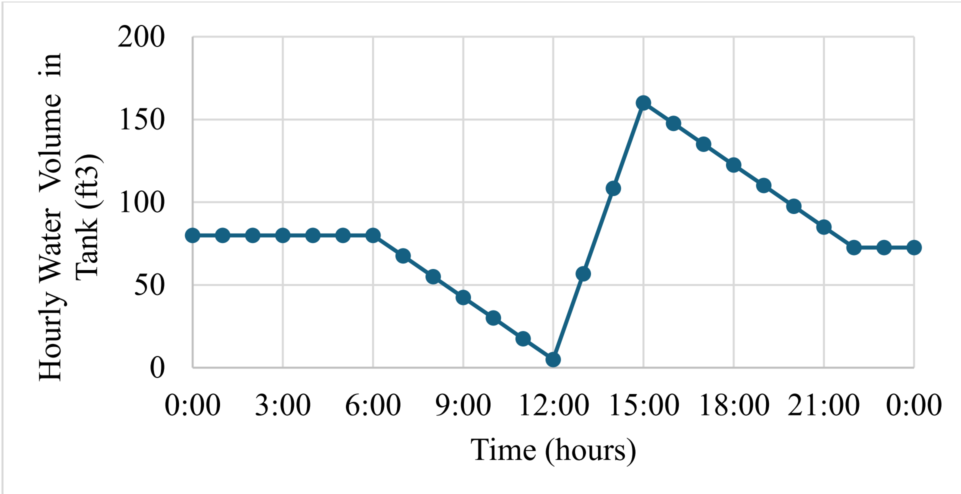
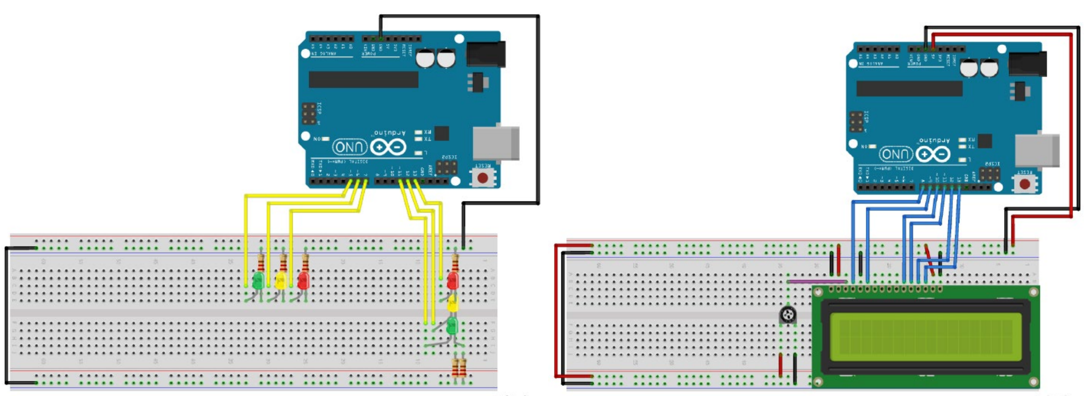


Figure 2. Faculty led development of Excel graph for hourly water volume (constant demand 6:00am-10:00pm and constant supply during peak sun hours 12:00-3:00pm.

DB 2 Monitoring and Feedback System: Engineering concepts including circuit construction utilizing breadboards and electronic sensors, feedback systems using alerts, and introductory coding are taught using Arduino components and provided codes. Students complete a series of seven self-guided Arduino tutorials including use of LEDs, buzzer alarms, a distance meter, and LCD screens (Figure 3). Student teams use this knowledge to develop a water tank monitoring system using the distance meter assumed to be mounted at the top of the water tank to determine water volume in the tank and a feedback system using a minimum of two alert systems. Students are permitted to combine and edit the previously provided codes for the final monitoring and feedback system but must comment out all lines of code, and the use of AI generated code is permitted if commented out and sufficiently tested on their constructed circuit. Tinkercad (Autodesk, Inc.) is also used for circuit construction and code verification (Figure 4). This design brief emphasizes humanistic factors as buzzer alerts are ineffective for students with hearing impairments. Students must determine where alerts will be incorporated throughout the school campus and how full and empty the tank will be for the alerts to trigger.



(a) LED lights circuit for tutorial **(b) LCD screen circuit for tutorial**

Figure 3. Breadboard figures for Arduino tutorials

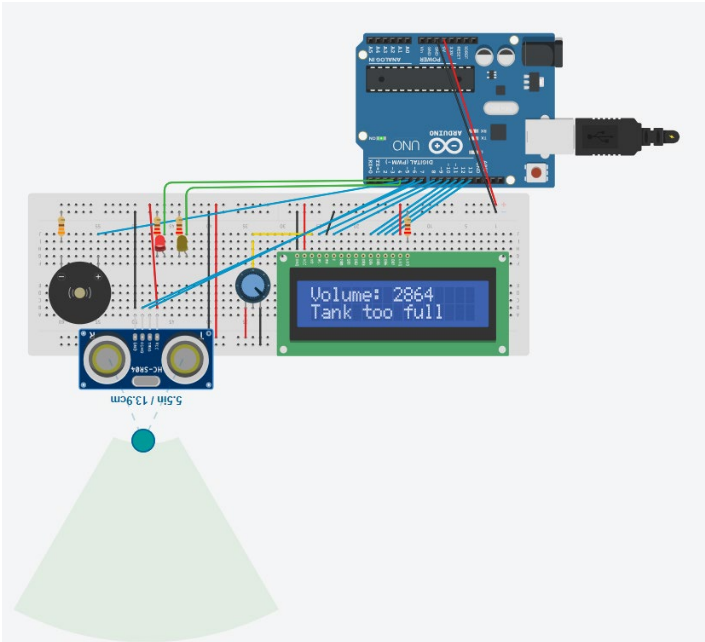
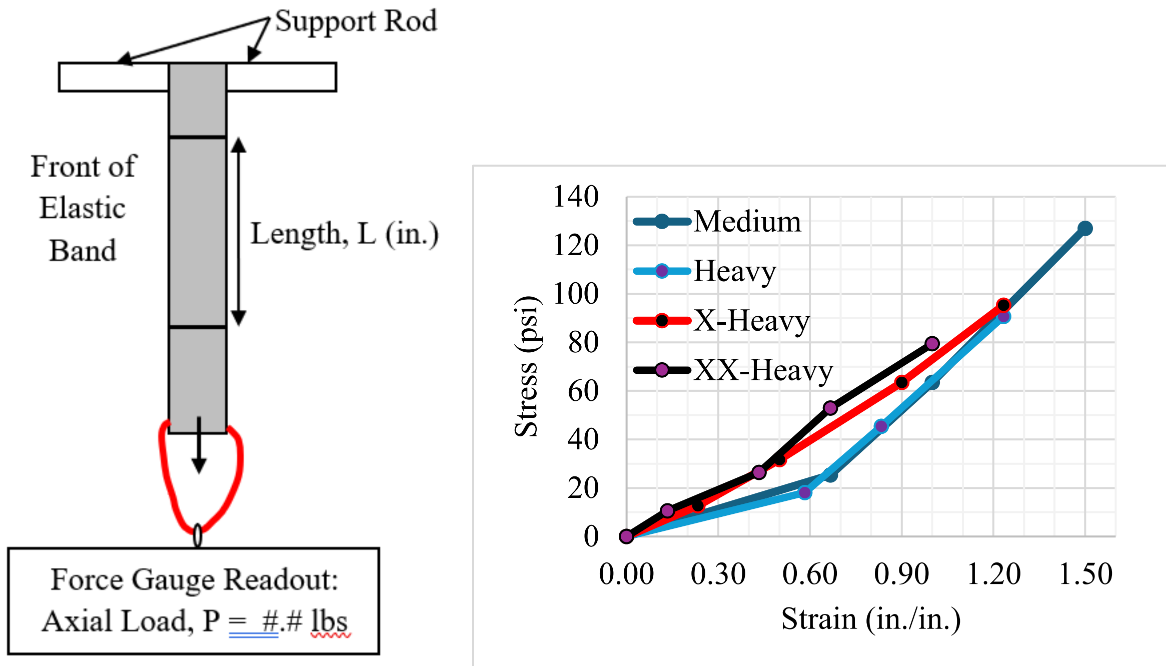


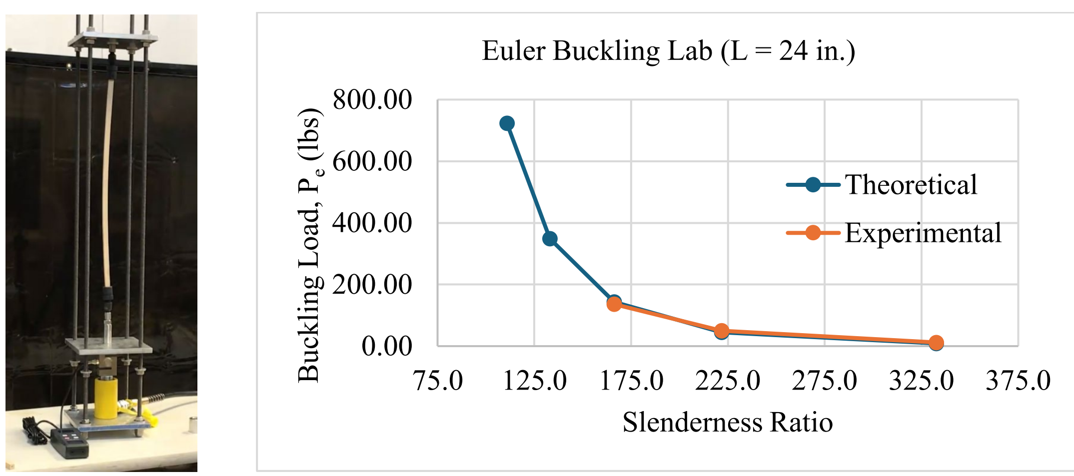
Figure 4. Tinkercad simulation of students developed tank monitoring system (team missing units for volume, gallons)

DB3 Support Structure: Moment of inertia, stress-strain relationships, and tension and compression axial load behavior are taught using a combination of lectures, hands-on (Figure 5) and demonstration (Figure 6) laboratories, and guided Excel spreadsheeting. Following, student teams are tasked with sizing a rectangular platform to support their tank, monitoring system, and to provide access for community members to the tank. Using the platform and previous designs as well as a spreadsheet that calculates the compression capacity of both square wood columns and steel tubular columns with various bracing locations, student design columns for their water tower considering humanistic aspects of construction, factors of safety (risk), and sustainability as well as other broader impact topics.



(a) loading graphic **(b) stress-strain graphs of different thickness bands**

Figure 5. Fitness band lab



(a) test setup **(b) effect of slenderness ratio on buckling load**

Figure 6. Column buckling demonstration lab (1/4 in., 3/8 in., and ½ in. square columns are tested for experimental verification of theoretical Euler buckling capacity).

Student teams submit a design brief memo for each technical design brief using a memo template that mirrors the engineering design process. Teams must clearly state the problem and point of view, empathy related to design criteria and constraints, ideation, and planning of their designs and calculations or testing. Proper technical writing and report formatting requirements such as tables of contents and figure and table captions are reinforced with each submission. While faculty feedback on the design briefs is provided, the feedback is not utilized by the students for design reflection or iteration but rather improvements to future writing. Throughout the technical design briefs, students develop a common engineering skill set including unit conversion, calculation formatting, Excel spreadsheeting, laboratory data collection and analysis, and technical writing format. Some lectures are delivered via short videos using an "inverted classroom" approach so that the majority of classroom time is spent with demonstrational and active learning activities. Throughout the projects, students gain valuable skills regarding teamwork, communication, problem solving, and data collection and analysis.

Conceptual engineering design project

During the humanitarian design project, students have been introduced to the beginning of the engineering design process (Figure 1). However, they have not had much opportunity to practice these skills, as the humanitarian design project focused on the plan-test phases and introducing basic technical concepts. To allow students to practice these skills, the conceptual engineering design project prompts students to "improve the lives of their fellow students on campus" through engineering design and prototyping.

As students themselves, it is easier for them to empathize with the intended user-group, making this project appropriate for the students. In the empathize stage, students are taught to use ethnographic research techniques and more traditional research methods. Ethnographically, students interview the intended user-group. This promotes students learning how to interact with users and develop interview skills. Students are also encouraged to develop surveys to get a broader scope of understanding within their user group and are required to present the results of the surveys in graphical format. They also are required to perform a literature review of the problem they find through the other research methods and any potential solutions that already exist.

Since the students have already completed one project with heavy guidance from the instructors, the conceptual engineering design project is intended to be more student-led. Gantt Charts were introduced and implemented to allow students to learn basic project management and time management skills.

Students are required to write a project proposal, guided by a provided template. During this time, students are also introduced to concepts of entrepreneurship. Namely, they discuss why a proposal is important and then they are introduced to the concept of prototyping.

A core concept the faculty wanted to instill in this course was prototyping and the various resources they have available on campus to assist them in prototyping. Instructors go over low, medium, and high-fidelity prototypes and why prototyping is a critical phase of the design process. Students are introduced to the Innovation Lab - a maker space that is fully stocked with materials, tools, and resources for a variety of prototyping techniques. The Innovation Lab has provided the course with a 3D-printing tutorial, where students must print a keychain with their name for credit. This ensures that students can use 3D printing in their prototypes for class and ensures they have at least one hands-on experience with this space in their first-year. To support this effort, the students also are introduced to OnShape [18] for 3D modeling (Figure 7). OnShape was chosen for its ease of use, cloud storage, and open-source access. Since the Innovation Lab operates within its own budget and supports the entire college, the classroom is also stocked with a prototyping cart. This cart has basic materials like fabric, glue guns, recycled cardboard, etc. for students to use in their prototyping.

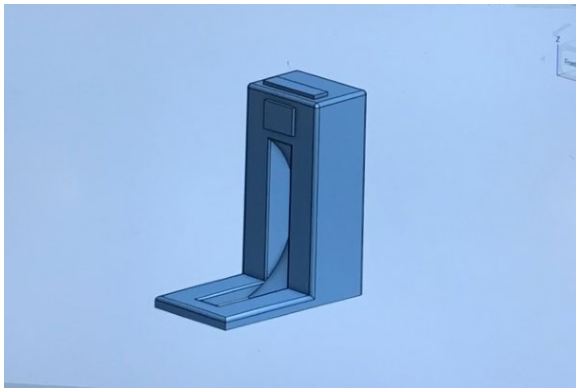


Figure 7. Onshape [18] prototyping of electric bicycle docking and charging

Conceptual projects are presented in either a presentation day or classroom walkabout. Students prepare formal slide presentations and present their prototypes. Feedback grids (Figure 8) are used for reflection. Examples of student work are provided in Figure 9.

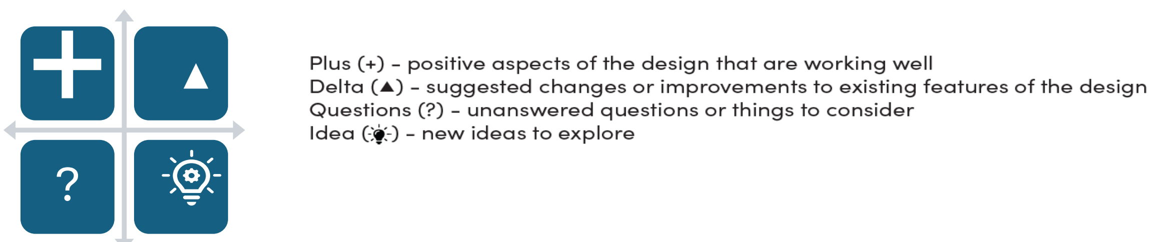
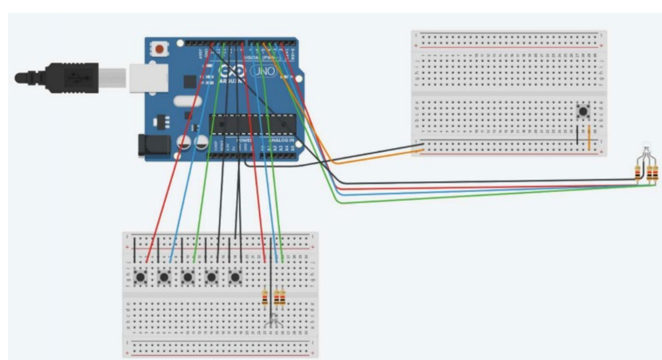
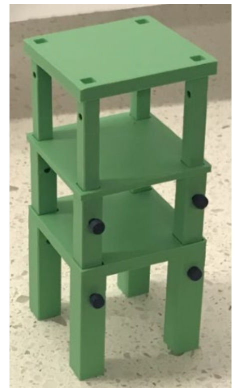


Figure 8. Feedback grid used for evaluation of prototypes



(a) Laundry App-MIT App Inventor [19] (b) Tinkercad dorm room monitoring system



(c) Transportation prototyping of campus bike route **(d) Adaptashelf for dorm rooms**

Figure 9. Samples of student prototypes

Finally, the College of Engineering supports a competition for the students' prototypes. The Freshman (FRESH) EGR 1200 Prototype Competition is run by the College's Engineering Entrepreneurship Program and highlights the top student group in each section of the course. The goal is to reward students who have shown mastery of the design process and generated an excellent, novel solution to a real problem on campus. These student teams should also have a well-developed prototype to demonstrate their solution. This competition has inspired additional creativity in student work and has been a motivator for more substantial prototypes. The competition culminates in a poster and prototype session that is judged by faculty and administration in the college of engineering.

The revised course structure emphasizes iterative, team-based projects that integrate technical analysis with design application, addressing a curricular gap in developing students' understanding of the engineering design process.

Methods/Assessment

A work-in-progress companion paper provides a complete summary of the methods used for course assessment [20]. Course assessment surveys were used to capture students' perspectives on engagement, confidence, perceived importance of learning objectives, and overall feedback. The data collected included both Likert-scale (quantitative) items (Table 1) and open-ended (qualitative) questions. Quantitative data were analyzed descriptively (mean, median, IQR), with additional reliability testing (Cronbach's alpha) to assess internal consistency and are described in more detail in a companion paper. Qualitative responses were inductively coded to identify emerging themes and provide contextual insights.

Table 1. Likert-scale descriptions for course assessment surveys

Engagement	Pre/Post Importance	Code
Strongly disagree	Not at all important	1
Somewhat disagree	Slightly important	2
Neither agree nor disagree	Somewhat important	3
Somewhat agree	Important	4
Strongly agree	Very important	5

Results

An 11-question post-survey (Table 2) on a 5-point Likert scale was used to evaluate student engagement. Question E1 measures student's perceived engagement as a whole, while other questions (E2 through E11) evaluate components of engagement. A Cronbach's $\alpha = 0.92$ indicates high internal consistency of data across all questions leading to an average engagement of 3.9 ± 0.8 ($n = 125$). Students reported particularly strong engagement with practical elements of the course, such as participating in class activities and a sense of accomplishment upon completion of projects. Items measuring students' initiative, reflection, and collaboration were strongly associated with overall engagement, reinforcing that hands-on, team-based learning experiences were key drivers of engagement. Five broad positive themes appeared in the qualitative data (Table 3). Some room for growth was observed in Engagement 8 and 9. Themes for improvements are summarized in Table 4 with 32 students' suggesting "no improvements."

Table 2. Course survey questions related to evaluation of student engagement

Item	Descriptive statement (N=125)	Mean	Std Dev	Median
E1	I feel engaged in the course	4.01	1.10	4
E2	I consistently prepare for class	4.14	1.09	4
E3	I put a great deal of effort into advancing my learning in the course	4.07	1.03	4
E4	I am challenged to learn more than I expected in this course	3.99	1.17	4
E5	I enjoy my time in this class	3.88	1.23	4
E6	I actively participate in class activities and discussions	3.95	1.07	4
E7	I seek help from my instructor or peers when I have difficulty understanding the material	4.19	1.01	4
E8	I regularly review and reflect on the course content outside of class	3.60	1.08	4
E9	I take initiative to explore topics beyond the course requirements	3.48	1.08	4
E10	I find myself thinking about the course topics even outside of class time	3.70	0.96	4
E11	I feel a sense of accomplishment when I complete tasks and activities in class	4.42	0.89	5

Table 3. Positive themes for student engagement

Theme	Description	Example Quote	Number of mentions
Hands-on activities/projects	Physical, practical tasks (e.g., Arduino, CAD, design briefs, building models).	"I loved the physical hands-on aspect of this course, especially the Arduino project."	43
Group work/collaboration	Team projects, peer interaction, working with others.	"Working in teams helped me stay engaged and learn how to collaborate effectively."	35
Learning new skills	Gaining technical or design skills; new concepts.	"The course taught me CAD and coding, which I had never done before."	24
Creative/fun aspect	Elements described as enjoyable, interesting, or innovative.	"The design briefs were fun and allowed me to be creative."	16

Instructor/course quality	Praise for course design, clarity, or instructor's role.	"Great professor and a well-organized curriculum kept me interested."	2

Table 4. Themes for improving student engagement

Theme	Description	Example Quote	Number of mentions
No improvements (positive feedback)	***Students said nothing needed improvement / no challenges reported.***	***"No issues at all—it was a great experience overall."***	***32***
Time constraints/personal challenges	Issues like workload, time management, external life challenges.	"Balancing the workload with other classes was difficult at times."	21
Group issues	Problems with group dynamics, participation, or communication.	"Some group members didn't contribute equally, which was frustrating."	16
Lectures (too long/boring)	Complaints about lecture format, length, or engagement level.	"The lectures sometimes felt long and hard to focus on."	8
Lack of background knowledge/confusion	Struggles with understanding course content or unclear instructions.	"I sometimes didn't feel prepared enough for the technical parts."	2

A 17-item course structure, delivery, and outcome evaluation on a 10-scale (Table 5) demonstrated excellent reliability (Cronbach's $\alpha = 0.94$), validating the scale's consistency. The highest-rated aspects centered on hands-on activities and project-based learning. For example, students overwhelmingly agreed with Item C10 "the hands-on activities enhanced my understanding" (Mean = 8.65, Median = 9.0) and Item C14 that they felt well-prepared for future design work (Mean = 8.44, Median = 9.0). Similarly, projects were noted for their strong alignment with course objectives (Item C11, Mean = 8.32, Median = 9). A qualitative survey of the most valuable aspects of the course (Table 6) highlights similar trends and includes hands-on learning, teamwork/collaboration, and skill development. Areas for improvement include course structuring as identified in Items C3 and C4, which may relate to pacing, organization, and integration. Qualitative survey of areas to improve included only one theme: lecture/content delivery being dull or unclear (10 mentions).

Table 5. Course structure, delivery, and outcome evaluation

Item	Course evaluation statement (N = 66)	Mean	Std Dev	Median
C1	The course content aligned well with my expectations for an engineering design course	7.73	1.78	8
C2	The course content helped me understand the engineering design process	8.21	1.68	8
C3	The course was well-structured to support my learning	7.02	2.29	7
C4	The course was well-structured to support my engagement	7.14	2.43	8
C5	The topics and activities were sequenced logically throughout the semester	7.79	2.03	8
C6	The instructors communicated the course objectives clearly	7.61	2.28	8

C7	The instructors communicated the course content clearly	7.35	2.22	8
C8	The instructors created an engaging learning environment	7.58	2.22	8
C9	There were plenty hands-on activities in class	8.27	1.8	9
C10	The hands-on activities enhanced my understanding	8.65	1.35	9
C11	The projects were aligned with the rest of the course	8.32	1.58	9
C12	The projects supported my learning	8.17	1.88	9
C13	The course helped me to think critically and iteratively during the design process	8.27	1.53	8
C14	I feel prepared to do more design work in my future classes	8.44	1.33	9
C15	I feel prepared to do design work at an internship	6.92	2.23	7
C16	The course met its stated learning objectives	8.06	1.81	8
C17	The course increased my excitement about pursuing engineering	8.03	1.89	8

Table 6. Positive themes in qualitative survey of course structure, delivery, and outcome

Theme	Description	Example Quote	Number of Mentions
Hands-on learning	Practical activities such as projects, building, and labs that enhanced learning.	"Doing the different projects helped because it gave me experience with a lot of different aspects of engineering that I may need in the future"	13
Teamwork/ collaboration	Working with classmates in teams or groups.	"The team building and design process from start to finish"	9
Skill development	Gaining specific engineering or problem-solving skills.	"Learning what an engineer does and the design process behind these practices."	5

Pre- and post-surveys of perceived importance of each course learning objective (see Appendix A) were evaluated on a 5-point scale with 52 students completing both surveys in entirety and mean, $\bar{x}$, standard deviation, s, and median, Q_2, values show in Table 7. Increases in mean, $\bar{x}$, values for the pre- to post-survey competencies (Figure 14) were Social Responsibility 3.49±0.97 to 4.40±0.69; Engineering Design 3.63±0.97 to 4.42±0.68; Teamwork and Communication 3.85±1.00 to 4.53±0.63; and Technical Skills 3.52±1.07 to 4.24±0.87 (post). Increases in mean values for each competency area were statistically significant (*p-values* $< 6 \times 10^{-19}$) demonstrating that the course design and delivery were successful.

Table 7. Pre- and post-surveys of perceived importance of each course learning objective (L.O.)

L.O.	Pre-Survey			Post-Survey		
	$\bar{x}$	s	Q_2	$\bar{x}$	s	Q_2
SR1	3.58	1.100	4	4.38	0.713	5
SR2	3.32	1.052	3	4.35	0.738	4.5
SR3	3.64	0.982	4	4.43	0.694	5
SR4	3.38	1.096	3	4.26	0.836	4
SR5	3.49	0.912	3	4.38	0.657	4
SR6	3.51	1.012	4	4.43	0.721	5
SR7	3.26	0.880	3	4.38	0.713	5

L.O.	Pre-Survey			Post-Survey		
	$\bar{x}$	s	Q_2	$\bar{x}$	s	Q_2
TC1	3.88	1.132	4	4.45	0.695	5
TC2	3.87	1.001	4	4.57	0.665	5
TC3	3.90	1.053	4	4.57	0.636	5
TC4	3.77	0.974	4	4.55	0.637	5
TC5	3.81	1.001	4	4.47	0.668	5
TC6	3.77	0.974	4	4.51	0.639	5
TC7	3.64	1.076	4	4.42	0.692	5

ED1	3.72	1.063	4	4.47	0.668	5
ED2	3.53	0.932	4	4.36	0.787	5
ED3	3.47	1.067	3	4.38	0.686	4
ED4	3.66	1.055	4	4.40	0.743	5
ED5	3.43	0.971	3	4.38	0.686	4
ED6	3.58	0.929	4	4.36	0.682	4
ED7	3.74	1.003	4	4.40	0.716	5
ED8	3.75	0.918	4	4.47	0.668	5
ED9	3.58	1.073	4	4.38	0.740	5
ED10	3.47	0.973	3	4.30	0.696	4

TS1	3.74	1.041	4	4.40	0.716	5
TS2	3.40	1.115	3	4.21	0.885	4
TS3	3.42	1.216	4	4.15	1.026	4
TS4	3.40	1.166	4	4.04	1.109	4
TS5	3.36	1.128	3	4.11	0.974	4
TS6	3.55	1.048	4	4.23	0.891	4

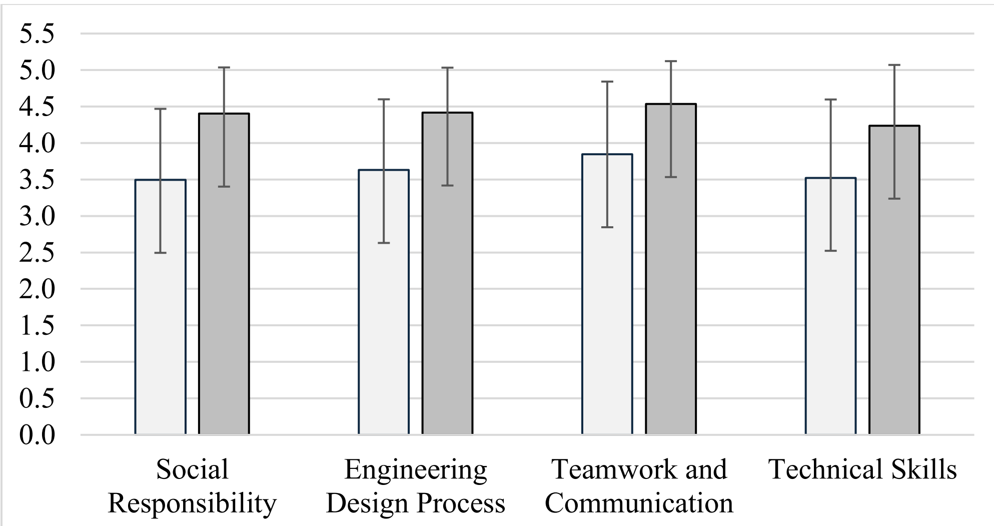


Figure 10. Perceived importance of four course competencies using averages of survey results for individual learning outcomes

Impact and Lessons Learned

The new course serves as each engineering student's first introduction to the engineering profession and Villanova University's engineering curriculum. When asked about the most valuable aspects of the course, students repeatedly praised the hands-on projects, teamwork experience, and opportunities to develop critical design and problem-solving skills. These student-praised items all match learning objectives from the core competencies developed by the initial redesign committee. Results indicate that a cohesive, design-centered approach supports student engagement and confidence across technical and professional competencies. The redesign effectively integrates hands-on, project-based, team-based learning with engineering analysis, highlighting the value of iterative, team-based design in the first-year engineering curriculum.

It became clear during course development that a course coordinator is essential for managing consistent content, delivery of materials, and supplies. This position required college funding which was secured. All course faculty have weekly meetings with the coordinator to discuss content, challenges, and future revisions. An end of semester report documenting course modifications as well as suggestions for continuous improvement is generated by the course coordinator. Students identified course challenges including group dynamics, time constraints, and dull lectures. Course modifications have been made to address these challenges and will be further assessed.

Classroom space that supports collaborative work is also essential in this team-centered project-based learning environment. A recent expansion of the engineering building created collaborative learning classrooms with stations accommodating six- to eight-student teams with a centralized monitor, allowing student groups to work together more effectively. This room also provides space for prototyping supplies and in-class hands-on activities. Relatedly, the college is seeking solutions to reduce class sizes, which currently can be as high as 45 students. All sections have a teaching assistant to aid in providing personal attention for students, but a lower faculty-student ratio would be preferred. The main barrier to success is faculty loading, as this course is staffed by each engineering department providing 1-2 faculty to teach this course. There is no “first-year department” or equivalent within the college.

Faculty who taught the previous course also recommend changing the humanitarian engineering project every two to three years. While the structure and technical assignments for the course could remain the same, changing the project will discourage students from seeking answers from upperclassmen and will also prevent project solutions from being readily available online. Additionally, changing the project will ensure the project remains relevant to the current day. Faculty also mentioned the need for a reduction in the number of assignments. The current goal is to combine the technical design-briefs into one assignment. This ensures the content remains while reducing student and instructor workload.

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Appendix A

Numbers in parentheses represent ABET outcomes mapped to the learning outcome.

A. Engineering Profession & Social Responsibility
   1. *(SR1)* Design solutions for real-world problems in partnership with communities in human-centered design (2, 4)
   2. *(SR2)* Examine data about environmental issues (e.g. climate change, energy and water use, scarcity and pollution, air quality waste management, toxicity, etc.) including consideration for past/current/future and local/regional/global impacts (4)
   3. *(SR3)* Explain the environmental and social impacts of designs created by others (4)
   4. *(SR4)* Recognize that some communities (e.g. communities of color, rural communities, etc.) have historically been negatively impacted and/or intentionally marginalized, and continue to be disproportionately negatively impacted by engineering activities (4)
   5. *(SR5)* Explain the role of social responsibility and social/environmental justice in the engineering profession (i.e. policies, laws, social justice, etc.) (4)

B. Engineering Design
   1. *(ED1)* Obtain, organize, and assemble information from primary and secondary sources (e.g. stakeholder interviews, systematic literature reviews, product archeology) to identify an unmet need/problem (2)
   2. *(ED2)* Determine engineering specifications based on design constraints for a specific proposed solution that are quantified, measurable, testable, and benchmarked (2)
   3. *(ED3)* Develop engineering solution options (conceptual design ideas) for a specific need/problem (2)
   4. *(ED4)* Assemble a diverse set of concepts that meet stakeholder needs and engineering specifications (2)
   5. *(ED5)* Select the concept that best meets the stakeholder needs and engineering specifications, while considering external impacts (social, political economic, environmental), using a decision matrix or similar tool (2, 4)
   6. *(ED6)* Create a prototype/proof-of-concept (2)
   7. *(ED7)* Use analytical equations to determine the efficacy of the prototype (6)
   8. *(ED8)* Use fundamental methods to analyze data (6, 7)
   9. *(ED9)* Use basic data visualization tools to report data (6)

C. Teamwork & Communication
   1. *(TC1)* Demonstrate ability to work well with others, across organizations, disciplines, and cultures (5)
   2. *(TC2)* Demonstrate active participation in team activities and decision-making (5)
   3. *(TC3)* Demonstrate ability to share workload (5)
   4. *(TC4)* Communicate overall design process and proposed solution to peers and stakeholders (3)
   5. *(TC5)* Reflect on individual and overall team performance (5)

D. Technical Skills

1. *(TS1)* Identify and apply electrical engineering design concepts including Ohm's law and an understanding of circuit schematics and breadboarding (1, 6, 7)
2. *(TS2)* Identify and apply computer engineering design concepts including developing/modifying basic flowchart and/or Arduino programming (1, 6, 7)
3. *(TS3)* Identify and apply civil engineering design concepts including basic statics and mechanics equations to analyze and design axial and flexural members (1, 6, 7)
4. *(TS4)* Identify and apply mechanical engineering design concepts such as fluid flow and pump selection (1, 6, 7)
5. *(TS5)* Identify and apply chemical engineering design concept(s) such as mass balance (1, 6, 7)