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WIP: An Integrated Introductory Engineering Course Led by Civil Engineering Faculty

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WIP: An Integrated Introductory Engineering Course Led by Civil Engineering Faculty

Abstract

First-year engineering experiences are crucial in influencing student persistence, identity development, and career paths. However, introductory engineering courses can be either too broad to foster a disciplinary identity or too narrow to accommodate diverse engineering students. This Work-in-Progress (WIP) paper presents early findings from the redesign of a first-year engineering course led by civil engineering faculty and serving both civil and mechanical engineering students.

The course is structured around an interdisciplinary, project-based framework emphasizing transferable competencies in engineering design, teamwork, and technical communication. Three signature projects, the Site Visit Project, the K'NEX Bridge Design Project, and the Engineering Design Challenge, anchor the curriculum. Beginning in Fall 2024, targeted revisions were implemented to strengthen disciplinary inclusivity. Rather than creating discipline-specific tracks, the intervention embedded mechanically grounded analysis within shared design challenges and diversified site visits to include more mechanically intensive contexts. Faculty instructional framing was intentionally revised while maintaining consistent assessment rubrics.

Using nationally normed IDEA survey results, DFW rates, mean GPA trends, and major-disaggregated grade analyses from Fall 2021 through Fall 2025 (N = 542), this study examines longitudinal performance patterns before and after interdisciplinary revisions. Results indicate declining DFW rates for both majors, with proportionally larger reductions among mechanical engineering students, who had previously exhibited higher risk. Mean GPA trends show convergence between mechanical and civil engineering students by Fall 2025, suggesting improvements distributed across performance levels. IDEA survey results consistently reflect strong student perceptions of teamwork, applied learning, and professional skill development.

Although causation cannot be established, the temporal alignment between integrative instructional revisions and narrowing performance gaps suggests that expanded interdisciplinary representation may enhance alignment between course design and the needs of a multi-major student population. These findings contribute to emerging conversations about how faculty

disciplinary background and intentional instructional framing influence inclusive learning environments in introductory engineering education.

1. Introduction and Motivation

First-year engineering experiences play a critical role in shaping students' academic persistence, professional performance and engagement, and long-term engagement in engineering pathways [1]. Prior research has shown that early exposure to authentic engineering practice, teamwork, and design thinking can significantly influence students' sense of belonging and confidence, particularly during the transitional first year of college [2], [3]. As a result, many engineering programs have adopted common first-year or introductory engineering courses intended to provide a shared foundation for students across multiple majors [4], [5].

Although introductory engineering courses are widely adopted, they continue to encounter a persistent design challenge. Courses designed to be broadly scoped can help introduce students to engineering as a profession, but they may also weaken the sense of disciplinary identity and perceived relevance [6], [7]. Conversely, courses that are too narrowly focused might alienate students whose intended majors are underrepresented in course content or examples, limiting their exposure to multidisciplinary perspectives essential for modern engineering collaboration [8]. This tension is particularly pronounced in programs with limited faculty coverage across disciplines, where introductory courses—though intended for all engineering majors—are often taught by faculty from a single discipline. As a result, students may receive limited exposure to the inherently multidisciplinary nature of engineering practice early in their education, potentially reinforcing narrow conceptions of engineering roles and weakening awareness of cross-disciplinary collaboration [9].

Accordingly, there is a growing motivation to design first-year engineering experiences that balance disciplinary authenticity with inclusivity, promote early identity development, and cultivate transferable professional skills across majors—an approach consistent with calls to integrate technical knowledge, professional skills, and identity formation early in engineering education [10]. While the literature emphasizes the value of hands-on, reflective, and authentic learning experiences, there remains a need for empirical case studies examining how faculty disciplinary background shapes course design and student outcomes in multi-major settings with staffing constraints [1], [3], [6].

This Work-in-Progress (WIP) paper addresses that gap by presenting early quantitative performance trends and instructional design reflections from the redesign of a first-year engineering course led by civil engineering faculty and serving both civil and mechanical engineering students. The course is structured around an interdisciplinary, project-based framework that develops core engineering competencies such as design, technical communication, teamwork, and professional development. Students participate in scaffolded activities including site visits, technical reports, oral presentations, and hands-on team design challenges—such as the K'NEX Bridge Project and the Engineering Design Challenge—which reflect iterative design processes from concept to testing. Emphasizing broadly applicable skills such as constraint-based design, structured teamwork, technical documentation, and project planning, the course is intentionally designed to avoid privileging any one discipline.

To evaluate this course design, the study examines how a first-year engineering course led by civil engineering faculty functions within a multi-major classroom serving both civil and mechanical engineering students. Specifically, it investigates whether intentional interdisciplinary revisions—particularly the integration of mechanically grounded analysis within shared design projects and site visits beginning in Fall 2024—are associated with changes in student performance and engagement. Using nationally normed IDEA survey results, DFW rates, mean GPA trends, and major-disaggregated grade analyses from Fall 2021 through Fall 2025, the study explores early indicators of course effectiveness and examines whether performance gaps between majors narrow following integrative instructional framing.

2. Institutional and Curricular Context

This first-year engineering course is offered at a regional, teaching-focused university with ABET-accredited civil and mechanical engineering programs. Students typically declare their major upon entry, and the course, taken in the first semester, serves as a required foundation for all engineering majors.

Enrollment in the course has ranged from approximately 100 to 125 students annually between Fall 2021 and Fall 2025. The course is typically offered in three sections each fall, with section sizes averaging 30–45 students. Mechanical engineering–related majors consistently represent the largest subgroup in the course, followed by civil engineering–related majors and a smaller proportion of exploratory or other majors. Thus, although instruction is delivered primarily by civil engineering faculty, the classroom composition reflects a multi-major environment in which disciplinary balance is a central design consideration.

As one of the earliest formal exposures to engineering, the course plays a pivotal role in shaping students' understanding of engineering practice, professional norms, and career possibilities. Beyond general education, mathematics, and science prerequisites (and a separate engineering graphics course), discipline-specific engineering classes are generally reserved for the sophomore year. This makes the introductory course essential for developing core competencies such as teamwork, design iteration, and communication, skills that are reinforced throughout the curriculum and culminate in the senior capstone design experience. These contextual and demographic characteristics informed subsequent curricular revisions to ensure equitable disciplinary representation within a civil-led instructional framework.

3. Course Design and Pedagogical Framework

3.1 Learning Objectives and ABET Alignment

This course is intentionally designed to cultivate transferable engineering competencies rather than discipline-specific technical mastery. It aligns with foundational ABET Student Outcomes shared across engineering disciplines, particularly Outcome 2 (engineering design), Outcome 3 (communication), and Outcome 5 (teamwork) [11], which serve as organizing principles for instructional design and assessment.

Students engage in an open-ended engineering design process under realistic constraints, including safety, sustainability, cost, and constructability. Design proficiency is assessed through scaffolded project deliverables evaluated using standardized rubrics, while communication and teamwork are assessed through technical reports, oral presentations, and structured peer evaluations embedded within team-based projects.

Although the interdisciplinary framing of projects has expanded in recent years to incorporate more mechanically oriented contexts, the assessment rubrics and performance criteria have remained consistent. This stability enables improvements in student outcomes to be interpreted as enhanced performance on the same ABET-aligned measures rather than as changes in grading standards. Through this skills-oriented structure, students gain early exposure to authentic engineering challenges while building a foundation that supports later discipline-specific coursework.

3.2 Signature Projects

Three major design projects anchor the course, each offering progressively complex challenges that emphasize core engineering skills through hands-on, team-based work.

- Site Visit Project (SVP): Students visit local engineering firms, infrastructure sites, or university labs to observe real-world engineering practice. These visits are followed by structured reflection assignments that connect observed professional activities to course themes such as ethics, communication, and the social dimensions of engineering. The SVP introduces students to the diversity of engineering roles and reinforces the importance of interdisciplinary collaboration in authentic settings.
- K'NEX Bridge Design Project: In this early-stage design challenge, student teams design, build, and test bridges using K'NEX components under specified load, geometric, and material constraints. The project cultivates skills in prototyping, structural reasoning, iteration, and data-driven redesign. While rooted in civil engineering concepts, it serves as a foundation for teamwork, technical reporting, and decision-making under constraints.
- Engineering Design Challenge (EDC): As the course capstone, the EDC engages students in open-ended design problems. In earlier iterations of the course, the EDC included projects such as cardboard cranes, a solar heater, and a water clock. These projects require teams to integrate engineering principles within constraints of sustainability, cost, and manufacturability. Students complete a series of deliverables, including Gantt charts, meeting notes, technical reports, and oral presentations, reflecting a full-cycle engineering design process. In its current form, the EDC incorporates additional interdisciplinary and mechanically oriented options, which are described in Section 4.

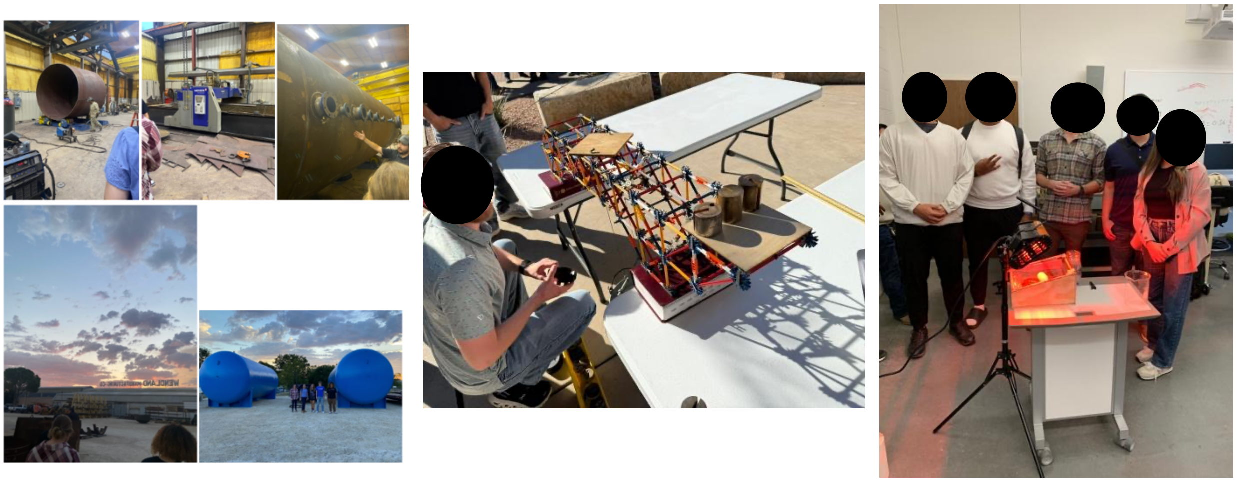

Figure 1. Sample photos of signature projects (Left: Site Visit Project (SVP), Center: K'NEX Bridge Design Project, Right: Engineering Design Challenge (EDC))

Each project emphasizes different facets of professional engineering practice, from site-based observation to iterative prototyping and systems thinking. Together, they provide students with early exposure to authentic design challenges, promote interdisciplinary awareness, and support the development of communication, teamwork, and project management skills. Recent updates have also aimed to enhance the relevance of projects for mechanical engineering students by incorporating more mechanically oriented design tasks and testing metrics. The evolution of these projects reflects an intentional effort to broaden disciplinary representation while maintaining common design expectations and assessment criteria. The project overviews for the K'NEX and EDC projects are available in Appendices A and B, respectively.

4. Course Interventions to Improve Disciplinary Balance

Building on the baseline structure described above, several targeted interventions have been implemented beginning in Fall 2024 to strengthen disciplinary inclusivity and better represent both civil and mechanical engineering perspectives in the course. These changes reflect a proactive effort to ensure that students from all intended majors see the relevance of course activities, even when instruction is primarily led by civil engineering faculty. Rather than creating discipline-specific tracks, the revisions were designed to embed mechanically grounded analysis within shared design challenges, ensuring that multiple engineering principles are engaged within a unified problem framework. **Table 1** provides a brief outline of the changes implemented, followed by a discussion on specific details.

Table 1. Course intervention timeline

<table>
<tr><th>Major Design Projects</th><th>Fall 2022</th><th>Fall 2023</th><th>Fall 2024</th><th>Fall 2025</th></tr>
<tr><td>Site Visit Project Locations</td><td>CE: 15 (65%)
ME: 8 (35%)</td><td>CE: 11 (48%)
ME: 12 (52%)</td><td>CE: 11 (58%)
ME: 8 (42%)</td><td>CE: 10 (45%)
ME: 12 (55%)</td></tr>
<tr><td>K'NEX Bridge Design</td><td colspan="2">- Simply supported truss at both ends
- One weight at midspan
- - Dimensional requirements for supports, span, and traffic envelope</td><td>- Same as previous</td><td>- Simply supported truss with overhang on one side
- Two weights, one at midspan and one on overhang (students could choose where to place)
- Dimensional requirements for supports, span, and traffic envelope</td></tr>
<tr><td>Engineering Design Challenge</td><td colspan="2">- Cardboard Crane: Max load held with hand operated mechanisms; main design focus on bending capacity of boom and capacity of vertical tower
- Water Clock: Use gravity to run clock for five minutes; main design focus on flow rate and gear mechanism
- - Solar Heater: Raise temperature of water from input tank to output tank in time limit; main design focus on thermodynamics</td><td>- Cardboard Crane: Same as previous
- Water Clock: Same as previous
- Solar Heater: Same as previous
- - Wind Turbine: Max voltage output and max wind load on structure; design focus on blade design to maximize voltage output with structural integrity a requirement</td><td>- Cardboard Crane: updated to require lifting mechanism to be motorized; design focus on generating enough torque to lift weight and overcome friction losses in system; structural integrity a requirement
- Water Clock: Removed
- Solar Heater: Removed
- Wind Turbine: Same as previous
- Solar Distillation: Raise temperature of air and water in time limit; main design focus on thermodynamics and sustainability</td></tr>
</table>

The first targeted change was to better match students with their preferred discipline when attending the Site Visit Project. With a ratio of approximately 60% mechanical engineering majors, 30% civil engineering majors, and 10% other majors in the course (precise values are given in **Table 2**), it is observed in **Table 1** that the participating site visit entities do not match this breakdown, with civil engineering being over-represented. As CE instructors, it is natural to have more interaction with the CE industry in the region, and hence better volunteer participation when contacting the entities by email. The instructors are working directly with the department's industry advisory council, alumni, and department chair to get better participation from the mechanical industry in the region, with the hope of achieving proportional representation for the Site Visits in the near future. Particularly in Fall 2025, site visits were diversified to include more facilities and firms with strong mechanical engineering involvement, such as those in energy, automobile, and manufacturing sectors, thereby expanding students' exposure to mechanically intensive applications.

The second targeted change occurred within the K'NEX Bridge Project. Largely unchanged for several years, the K'NEX Bridge Project was revised in Fall 2025 to include an overhanging truss bridge design, commonly seen in mechanical and hybrid structural systems. This adjustment exposes students to more complex structural forms and introduces mechanics-related considerations within the design process. Beyond geometric configuration, teams must reason through load paths, joint behavior, member force distribution, and failure modes, encouraging systems-level thinking rather than a purely civil structures strength exercise. In addition, the students had to reason through the testing phase, where they had control over the placement of the weight in two locations. Thus, students had the chance to optimize their structures in different ways to achieve the maximum load possible.

The final and most significant targeted changes have occurred within the Engineering Design Challenge. From Fall 2021-Fall 2023, students had three main projects to choose from:

- Cardboard Crane
    - Mainly chosen by civil engineering students interested in structural engineering
    - Chosen by some mechanical engineering students interested in gears/pulleys

- Water Clock
    - Mainly chosen by civil engineering students interested in water resources or environmental engineering, despite requiring intricate gear design to be completed successfully
- Solar Heater
    - Mainly chosen by mechanical engineering students interested in thermodynamic and heat transfer, or because it seemed less “civil engineering” than the other two options

While the above descriptions are anecdotal, the number of teams choosing the Solar Heater had increased steadily with the rising enrollment of mechanical engineering students in the department.

Noticing this trend, the instructors thought it prudent to add a project with more mechanical engineering principles. In Fall 2024, the Wind Turbine Project was added to the options for the Engineering Design Challenge (EDC). This project integrates mechanical engineering principles, including torque, rotational motion, and energy transfer, alongside structural and material constraints. Teams evaluate rotational efficiency, mechanical losses, and structural integrity under loading, requiring performance-based testing. It provides a systems-level design experience that encourages students to think critically about both performance and feasibility.

Following the success and popularity of the mechanical and civil engineering-integrated Wind Turbine Project, the instructors sought to make additional changes to the Engineering Design Challenge in Fall 2025. The Cardboard Crane Project was upgraded to include motorized components, introducing concepts such as power transmission, torque, and motion control. Students must account for gear ratios, lifting capacity, and mechanical efficiency in addition to structural strength. This modification preserved the project's structural foundation while expanding its relevance in mechanical engineering. The Solar Distillation Project was introduced as an interdisciplinary alternative to the previous solar water heater task, integrating thermodynamics, fluid systems, and sustainability concepts. Design evaluation includes thermal performance, evaporation rate, heat transfer efficiency, and system sealing considerations, requiring students to engage energy balance reasoning alongside fluid transport concepts. The Water Clock Project, previously part of the EDC, was removed due to consistently high failure rates in prior semesters. Its exclusion was based on instructional review and a desire to ensure that all EDC options provide a feasible and supportive learning experience for first-year students.

All updates were framed within the course's interdisciplinary mission, emphasizing shared design principles rather than discipline-specific silos. Importantly, these revisions broadened the contexts in which design competencies were demonstrated without altering the underlying assessment rubrics. While individual projects may emphasize certain disciplinary lenses more prominently, each requires students to integrate structural, mechanical, and systems considerations to produce a viable solution. Collectively, these interventions aim to offer a more balanced and inclusive experience, helping students from both civil and mechanical engineering pathways develop confidence and curiosity in their chosen fields through meaningful, hands-on engagement.

5. Assessment Methods

This Work-in-Progress study primarily analyzes institutional grade data (DFW rates and mean GPA by declared major) and IDEA course evaluation results collected across five fall semesters (Fall 2021–Fall 2025). These data provide longitudinal indicators of student performance and perceived learning within a multi-major classroom. In addition, the course employs embedded rubric-based evaluations of design, teamwork, and communication in major projects. While rubric structures remained consistent throughout the study period, detailed rubric score analysis is ongoing and will be reported in future work. The results presented in this paper, therefore, reflect quantitative performance trends under stable assessment criteria, with additional qualitative and rubric-level analyses planned for subsequent study phases.

6. Student Demographics and Sample Characteristics

Over five fall semesters (Fall 2021–Fall 2025), the introductory engineering course enrolled 542 students. This course is a required first-year class for all engineering students. The class demographic reflects the overall student body enrolled in the civil and mechanical engineering programs at the institution.

6.1 Enrollment Composition by Major

Across five fall semesters (Fall 2021–Fall 2025), total enrollment ranged from 97 to 126 students per year (Table 2). The course was consistently offered in three sections per semester.

Mechanical engineering–related majors constituted the majority subgroup each year, ranging from 54.6% to 65.1% of enrolled students. Civil engineering–related majors accounted for approximately 27.8% to 31.9% annually, with the remaining students classified as exploratory or enrolled in other related programs. Given that mechanical engineering students represent the largest proportion of the class, yet instruction is primarily delivered by civil engineering faculty, this demographic distribution reinforces the importance of designing projects and instructional framing that visibly integrate concepts from both disciplines.

Table 2. ME vs CE ratio from Fall 2021 to Fall 2025

Year	Total (n)	ME (n)	CE (n)	Other (n)	ME (%)	CE (%)
Fall 2021	97	55	28	14	56.7	28.9
Fall 2022	97	62	28	7	63.9	28.9
Fall 2023	119	65	38	16	54.6	31.9
Fall 2024	103	61	29	13	59.2	28.2
Fall 2025	126	82	35	9	65.1	27.8

6.2 Gender

Enrollment across all semesters was predominantly male, with male students comprising approximately 80.2% of the population. Female students represented 19.8% of total enrollment. While this gender distribution aligns with national trends in engineering, it highlights the importance of employing inclusive pedagogical approaches that support diverse participation and engagement.

6.3 Race and Ethnicity

The student population was racially and ethnically diverse. The two largest groups were Caucasian students (42.0%) and Hispanic students (38.7%), followed by African American students, international, Asian or Pacific Islander students, and American Indian/Alaskan Native students. A small proportion of students (1.1%) had unreported or unknown ethnicity. This diversity reflects the regional context of the institution and reinforces the value of culturally responsive teaching practices.

6.4 First-Generation Students

A defining characteristic of the student population was the high proportion of first-generation college students. Across all five semesters, 83.3% of enrolled students identified as first-generation. Given the well-documented barriers faced by first-generation students in engineering, this finding underscores the importance of structured support systems, reflective activities, and early exposure to professional contexts as central elements of course design.

6.5 Implications for Analysis

The demographic information presented in this section provides contextual background for interpreting course performance trends. The current Work-in-Progress analysis focuses primarily on aggregate outcomes and major-disaggregated grade trends (mechanical and civil engineering students). No inferential statistical comparisons across demographic subgroups are included at this stage. Future phases of the study may incorporate more granular analyses as additional data and methodological development allow.

7. Results and Preliminary Findings

7.1 Student Perceptions of Learning and Engagement (IDEA Survey Results)

End-of-semester IDEA (Individual Development and Educational Assessment) survey results consistently indicate strong student perceptions of learning, engagement, and instructional quality. The IDEA system is a nationally normed course evaluation instrument that compares student ratings across participating institutions and disciplines using adjusted percentile benchmarks. The IDEA system uses a 5-point Likert scale (1 = “no apparent progress,” 5 = “exceptional progress”) with scores converted to national percentiles for benchmarking.

In Fall 2024, for instance, 79% of students rated “Acquiring skills in working with others as a member of a team” at a 4 or 5, with a converted score of 63, which corresponds to performance in approximately the top decile of courses within the IDEA national comparison group. Similarly, students reported strong gains in applying course material to practical problems (converted average: 53) and in developing competencies relevant to professional practice (converted average: 49). These findings suggest that the project-based, reflective, and team-oriented course structure supports core engineering learning goals, particularly for early-career students. These findings reflect students’ self-reported perceptions of progress rather than direct measures of skill attainment. As such, IDEA results are interpreted as complementary to rubric-based assessments of design and teamwork performance described in Section 7.2.

7.2 DFW Rates, Grade Distributions, and Major-Specific Trends

To improve the interpretability of longitudinal performance patterns, Figures 2 and 3 present visual summaries of DFW rates and mean GPA trends by declared major from Fall 2021 through Fall 2025. Fall 2021–Fall 2023 serve as a multi-year baseline prior to major interdisciplinary revisions, while Fall 2024–Fall 2025 reflect implementation of mechanically integrated project enhancements and revised instructional framing. Including three pre-intervention semesters reduces the likelihood that short-term cohort variability is misinterpreted as results intentional course changes from this case study.

As shown in Figure 2, DFW rates declined for both mechanical engineering (ME) and civil engineering (CE) students over the five-year period. However, the magnitude of improvement differed by subgroup. During the baseline years (Fall 2021–Fall 2023), ME students exhibited consistently higher DFW rates than CE students. In Fall 2021 and Fall 2022, ME DFW rates were above 22%, while CE rates remained closer to 14%. This gap narrowed beginning in Fall 2023 and decreased substantially following the interdisciplinary revisions implemented in Fall 2024 and Fall 2025. By Fall 2025, ME DFW rates declined to below 10%, representing a reduction of more than 14 percentage points from Fall 2021. CE students also experienced improvement, with DFW rates decreasing to approximately 6% in Fall 2025. The narrowing performance gap suggests that the subgroup previously exhibiting higher risk (ME students) experienced proportionally larger gains following the interventions.

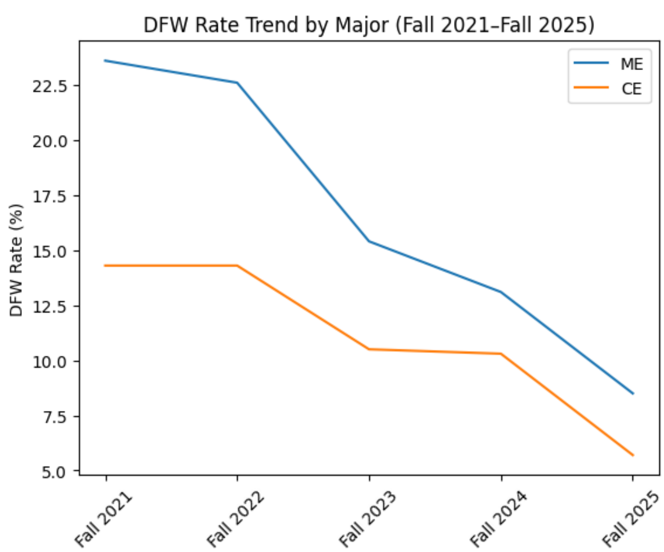

Figure 2. DFW rate trend by major (Fall 2021 - Fall 2025)

To examine whether improvements were concentrated only among marginal students or distributed across performance levels, mean GPA trends (A–F only, excluding withdrawals) were also analyzed (Figure 3). Across the five-year period, ME students demonstrated a steady upward trajectory in mean GPA, increasing from approximately 2.9 in Fall 2021 to above 3.3 in Fall 2025. In contrast, CE students began with higher average GPAs but showed more modest fluctuations over time, remaining relatively stable between 3.1 and 3.3. The convergence in mean GPA between ME and CE students by Fall 2025 indicates that improvements were not limited to reductions in DFW rates alone. Rather, gains were observed across achievement levels, including increased proportions of A and B grades among ME students. This supports the interpretation that performance growth occurred across the distribution rather than only at the lower end.

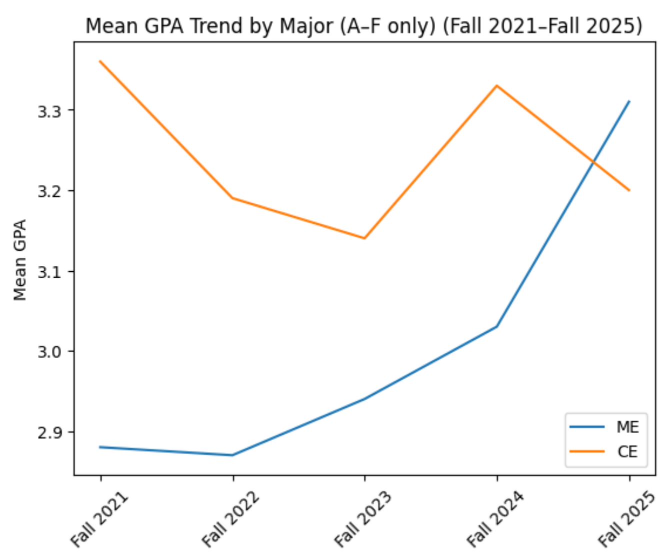

Figure 3. Mean GPA trend by major (A–F only) (Fall 2021–Fall 2025)

7.3 Instructional Framing and Faculty Role in the Intervention

It is important to clarify that faculty assignment did not change during the study period; the course continued to be taught primarily by civil engineering faculty. However, beginning in Fall 2024, instructional framing was intentionally revised to embed mechanically grounded analysis within shared design challenges rather than adding discipline-specific tracks. Faculty modified lecture examples, design prompts, and testing criteria to explicitly integrate structural, mechanical, and systems-level reasoning within each project.

Thus, the intervention involved deliberate shifts in pedagogical emphasis and performance framing—not merely new project topics—while maintaining consistent assessment rubrics. Although causation cannot be established, the temporal alignment between these integrative revisions and improved DFW and GPA trends suggests that expanded interdisciplinary representation may have strengthened alignment between instructional practice and the needs of a multi-major student population.

7.4 CE Faculty/Instructor Feedback

As civil engineering faculty, we often focus on one specific area of expertise or sub-discipline, performing related research and teaching the corresponding upper-level electives. Only by intentionally thinking about the disciplinary make-up of the students in the course would an instructor be led to consider the need for more mechanical engineering-related alternatives. One challenge for the CE faculty has been to research and integrate mechanical engineering concepts, including mechanisms, motors, controls, electricity, and heat transfer. With only basic knowledge from undergraduate courses taken a number of years ago, it has required effort to incorporate mechanical engineering principles into the designs. The integration is a work-in-progress, particularly in defining the project requirements and determining design efficiency, which are updated after each course ends by reviewing the students' experimental test data.

Furthermore, it is believed that integrating both disciplines will help prepare students to tackle systems-level problems encountered in the real world. Having both disciplines provides students with exposure to the other engineering field, either reinforcing their identity in their chosen major or enabling them to explore different engineering pathways.

7.5 Alignment with Study Objectives

The observed trends support the study's objective of examining how faculty disciplinary background and intentional course redesign influence student performance in a multi-major setting. Although faculty assignment remained constant, instructional framing was revised to more explicitly integrate mechanical and structural reasoning within shared design challenges. Following these changes, reductions in DFW rates, increases in mean GPA, and narrowing performance gaps between mechanical and civil engineering students were observed. While direct measures of disciplinary perception and identity are still under qualitative analysis, the quantitative performance trends and sustained positive IDEA ratings provide preliminary evidence that expanded interdisciplinary representation may be associated with improved alignment between course design and the needs of a multi-major student population.

8. Discussion and Limitations

This Work-in-Progress study examines the opportunities and challenges of delivering a multi-major first-year engineering course led primarily by faculty from a single discipline. The findings suggest that interdisciplinary integration can be meaningfully advanced through intentional instructional framing, even when faculty composition remains unchanged. While civil engineering faculty continued to lead the course, revisions beginning in Fall 2024 deliberately embedded mechanical reasoning within shared design challenges rather than introducing discipline-specific tracks.

Following these changes, reductions in DFW rates, increases in mean GPA, and narrowing performance gaps between mechanical and civil engineering students were observed. Improvements were distributed across performance levels, with gains evident not only in reduced DFW rates but also in increased proportions of A and B grades. Because assessment rubrics remained stable throughout the study period, these shifts can be interpreted as changes in student performance under consistent evaluative criteria rather than modifications in grading standards.

Although causation cannot be established, the temporal alignment between integrative instructional revisions and improved outcomes suggests that expanded interdisciplinary representation may enhance alignment between course design and the needs of a multi-major student population. In particular, mechanical engineering students—who constitute the majority subgroup—demonstrated proportionally larger improvements following the intervention, while civil engineering students maintained stable performance.

Several limitations should be acknowledged. This study reflects a single-institution context with moderate cohort sizes, limiting generalizability. The analysis relies primarily on grade distributions and nationally normed IDEA survey data, which provide indirect indicators of engagement and learning. Although major-specific trends were examined, the study does not yet include inferential statistical testing or controlled comparisons. Additionally, measures of disciplinary identity and perceived relevance are still under qualitative analysis and have not yet been fully integrated into the results presented here.

9. Future Work and Conclusion

Future research will build on this foundation by incorporating direct pre/post assessments of engineering self-efficacy, identity development, and perceptions of disciplinary fit. Ongoing qualitative analysis of student reflections and project artifacts will provide deeper insight into how instructional framing influences students' interpretation of disciplinary alignment. Longitudinal tracking will examine whether early interdisciplinary integration contributes to persistence and retention across engineering majors.

In conclusion, this WIP paper contributes to engineering education literature by exploring how faculty disciplinary background and responsive course design interact to shape first-year, multi-major learning environments. The results suggest that disciplinary balance can be strengthened not only through project selection but through explicit integrative framing and performance criteria embedded within shared design challenges. These findings highlight a practical strategy for institutions where introductory courses are staffed by faculty from a single discipline yet serve diverse engineering majors. By maintaining stable assessment standards while broadening disciplinary representation, programs may foster more inclusive early engineering experiences that support engagement, performance, and identity development across majors.

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Appendix A. Overview of K'NEX Bridge Design Project (KNEX)

K'NEX Bridge Design Project

REQUIREMENTS

Using the provided K'NEX parts, design and construct a bridge that spans 60 cm with a 20 cm overhang and includes a required traffic envelope beneath the bridge, 10 cm high and 10 cm wide (see Figure 1). The foundations for the bridge must rest in a 23.5 cm X 15.25 cm rectangle at each bridge abutment (see Figure 1). The bridge must be capable of carrying a total of 6 kg mass suspended from a 15 cm X 15 cm loading plate placed on top of the bridge at midspan and at the overhang (minimum weight for midspan is 5.5 kg and for overhang is 500 g). A general layout of the model bridge is shown in Figure 1.

The bridge will be loaded to the point of failure. The failure mass will be recorded (in kg), and the Strength to Weight Ratio (failure mass/mass of bridge) will be computed.

RULES

1. Each team will be provided a kit of K'NEX pieces. No other materials may be used to construct the bridge. Appendix A contains an inventory of the kit pieces. Teams should check the provided quantities.
2. If pieces are lost or damaged, please consult the HUB facilitator for replacements.
3. K'NEX pieces may not be altered in any way including, but not limited to, gluing, cutting, or welding.

TESTING

A random drawing will determine the order of testing. Teams should bring the bridges assembled to class on the day they are scheduled to test. Bridges will first be loaded up to the service design load of 5.5 kg for midspan and 500 g for overhang (Total 6 kg). Bridges successfully holding the service load of 6 kg for 30 seconds will then be incrementally loaded to failure either midspan or overhang. Once loading has begun, each team will have a total of 5 minutes to complete their load testing.

Requirements:

- ☐ Technical report submitted on time
- ☐ Clearance 10 cm (W) x 10 cm (H)
- ☐ Span, 60 cm
- ☐ Overhang, 20 cm
- ☐ Landing zone, 23.5 cm x 15.25 cm
- ☐ Only K'NEX parts provided

- ☐ 1.5 points for each discrepancy & cannot compete for bonus points

Calculating Strength to Weight Ratio

$$Strength\ to\ Weight\ Ratio = \frac{Failure\ Load\ [kg]}{Bridge\ Mass\ [kg]}$$

GRADING AND EVALUATION

Your grade for the project is based on performance and on each deliverable of the project. The percentages for each area are provided in Table 1.

All teams meeting the design requirements (dimensional limits and carrying a 6 kg mass with 500 g at the overhang) will receive a minimum of 15/15 points for performance. Teams failing to achieve the design capacity will be awarded points based on Table 2. Points will be deducted for bridges that fail to meet one or more of the dimensional requirements. Bonus points will be allocated to successful teams, based on the ranking of their Strength to Weight Ratio (across all course sections), according to Table 3.

Table 1: Bridge Project Grading

Category	Grade %	Time Allocation	Description	Type of Deliverable
Team Agreement	10	1-2 hours	Team Agreement as outlined in assignment	Team
Gantt Chart	10	1-2 hours	Gantt chart outlining project deliverables and timeline	Team
Meeting Notes and Feedback workshop	10	1 hour each	Completed notes outlining team info, individual ideas, meeting notes, final designs	Team
Oral Presentation	10	5-10 hours	Technical presentation that is neat, well-organized, informative, and professional	Team: Assigned Sections for Individuals
Technical Report	40	10-20 hours	Technical report following guidelines	Team: Assigned Sections for Individuals
Performance	15	20 minutes	Score based on meeting design criteria	Team
Participation	5		Project contribution based on team assessment	Individual

Table 2: Performance Points awarded based on total capacity

Mass Carried Total	Points
< 6 kg	12.75
8 kg	13.5
9 kg	14.25
≥ 10 kg	15

Table 3: Bonus Points (Strength to Weight Ratio)

Place	Bonus Points	Place	Bonus Points
1	5	5	1
2	4	6	1
3	3	7	0
4	2	8	0

Your model must adhere to the rules; deductions will be made if rules are violated. The model must be professional looking, well planned, and well executed. Teams are not eligible for bonus points if violating rules or not successful at carrying required 6 kg.

DELIVERABLES

All deliverables are described in detail in a separate document. All submissions will be done on Blackboard. When one team member submits, it should show for entire team.

- KB 1- Team Agreement
- KB 2- Gantt Chart
- KB 3A/3B/3C- Meeting Notes and Feedback Workshop
- KB 4- Oral Presentation
- KB 5- Technical Report
- KB 6- Performance (no submission required- assessed at Bridge Testing)
- KB 7- Peer Review

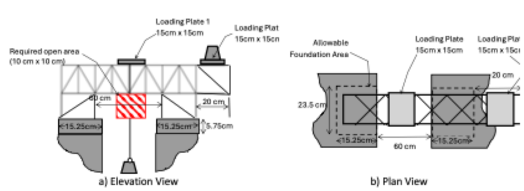


Figure 1: Dimensional requirements for model bridge (not to scale)

Appendix A: Bridge Kit Inventory

Image	Name	Approximate Mass /piece (g)	# pieces
	Bar, Gray	4.4	15
	Bar, Red	2.7	36
	Bar, Yellow	2.0	56
	Bar, Blue	1.3	60
	Bar, White	0.8	40
	Bar, Green	0.5	40
	Bar extender	0.6	10
	Connector, Orange	1.4	50
	Connector, Purple	0.8	0
	Connector, Black	0.6	20
	Connector, Blue	3.3	34
	Connector, Green	2.1	16
	Connector, Yellow	2.5	46
	Connector, Red	1.7	8
	Connector, Gray	2.2	73
	Connector, Lt Gray	1.3	6
	Connector, White	3.6	6

Appendix B1. Overview of the Engineering Design Challenge (EDC) - Wind Turbine

Engineering Design Challenge Project: Wind Turbine

1. OVERVIEW

Design, build, and test a wind turbine, predominantly constructed from recycled materials. The wind turbine must be capable of producing electricity to power a light string using wind supplied by a floor fan. The wind turbine must also meet a number of geometrical requirements. During testing, the wind turbine must operate on its own without student intervention.

The wind turbine must include these 4 component parts:

- Base, able to be anchored to or by a 10 lb gym weight
- Vertical tower
- Wind turbine blades, to be engineered by student groups
- Two electrical leads (positive/negative) from turbine to connect to light/multimeter

2. RULES

1. Dimension requirements:
    a. The entire device must fit in a 11 in x 11 in x 11 in crate.
    b. The vertical tower and turbine blades must be able to pass through a 6.25 in diameter hole. A template will be provided. Separation of parts is allowed.
2. For the power test:
    a. One 10 lb gym plate weight (approximately 9.25 in outer diameter with 1.5 in inner diameter) will be provided to anchor the wind turbine.
    b. A three-speed floor fan (like those used to dry carpets) will be set up a minimum of 12 in from the wind turbine and turned on to provide the wind source. The teams will decide which fan speed they wish to use during this test (only one speed will be used; fan is available to teams in HUB).
    c. Two electrical leads (positive and negative) must be provided to connect to light/multimeter.
3. For the strength test:
    a. The wind turbine must be held in place by the 10 lb weight.
    b. The wind tunnel speed will be increased until the judge determines failure. Failure will be at the discretion of the judge; however, any flying debris from your wind turbine will be considered a failure.
4. Materials:
    a. With the exception of the power generation device and wires, all construction materials for the wind turbine (base, vertical tower, turbine blades, locking mechanisms, etc...) will be made from recycled or repurposed materials.
    b. Recycled materials will include Plastics #1-7, Aluminum, Tin, Steel, Paper, and Cardboard. To check if your item meets the requirement, this website is useful.
        i. No glass of any kind is allowed in your design.
    c. Repurposed materials will be defined as any item at the end of its life and its inclusion in your design will help prevent trash/waste.

        i. If you use repurposed items, you must explain in your report/presentation what was used and how. Basically, you should explain how your including it in the design is more sustainable than its previous path.
            1. Example: you have an old appliance that will be thrown away. You choose to use the electric cord in your design.
            2. Example: you have scrap metal or wood comprising pieces too small for most jobs, so you use them in the design.
    d. For the power generation device, you may use purchased items. The total cost for these items should be less than $20.00. The instructors will provide an option for small DC motors and wiring should you wish to use that.
    e. 3D printed plastic pieces are allowed in the design of the power generation device and the wind turbine blades (not for the base or the vertical tower). You must prorate the cost of these printed items based on the cost of the plastic. In lieu of a more accurate number, ABS and PLA plastics sell for $20.00-30.00 per 2.2 lbs [1 kg].

3. TESTING

1. Power Test
    a. The final design will be placed 12 in from a floor fan to generate power. Teams will decide which speed they wish to use.
    b. The design must have two electrical leads to connect to the light source.
    c. Using only the wind from the fan, the wind turbine must power a light string.
    d. The voltage generated by the fan will be measured by connecting the output to a multimeter to record volts generated.
    e. For subsequent strength and lighting tests, the turbine may be moved closer to the fan at a speed of the team's choosing.
    f. The test will take less than 5 minutes per team.
2. Strength Test
    a. The final design will be placed in front of the floor fan, with the wind speed increased until failure. The wind speed at failure (fan setting) will be recorded along with distance from the turbine. At 12 in, the wind speed will be increased to the maximum speed, then the distance to the turbine will be reduced.
    b. Failure is at the discretion of the judge, but will include any flying debris from your design.
3. Calculate
    a. Power = Voltage X Amperage (P=VI)
    b. Maximum bending moment in the vertical tower
    c. Maximum RPMs of Turbine using Slo-mo Video capture or equivalent
4. Report all costs of your design and explain the use of recycled/repurposed materials.

3.1. REQUIREMENTS

- ☐ Fits in 11 in x 11 in x 11 in space
- ☐ Materials used meet requirements
- ☐ Wind turbine successfully powers light
- ☐ Wind turbine can be inserted through 6.25 in diameter hole.
- ☐ Wind turbine is only anchored by 10 lb weight.

– 5% for each discrepancy & cannot compete for bonus points

3.2. EFFICIENCY RATIO

Your "efficiency" will be measured relative to the rest of the class, including all three sections of the course. If your team did not spend any money on the project, $5.00 will used as the "Cost" in the formula.

$$Efficiency = 0.2\left[\frac{Max\ Distance\ Lights\ Up\ (in)}{12\ in}\right] + 0.2\left[\frac{6\ in}{max\ (Distance\ to\ Cause\ Failure\ (in);\ 2\ in)}\right] + 0.4\left[\frac{Max\ Voltage\ Measured\ at\ 12\ in\ minimum\ (V)}{2\ V}\right] + 0.2\left[\frac{\$20}{max\ (Cost;\$5)}\right] \qquad \textit{Equation 1}$$

4. GRADING AND EVALUATION

Your grade for the project is based on a combination of your design, how well you do in the demonstration and project, the final technical report, and the oral presentation of your work.

Design Scoring

Activity	Points
Base Score • Design Powers Light • Design Does Not Power Light • Design Does Not Meet Geometrical Requirements	 100% 85% 85%
Bonus Points (based on all 3 sections of ENGR 1201) • 1st Place • 2nd Place • 3rd Place	 +10% +5% +3%

5. FINAL PROJECT GRADE

Your grade for the project is based on your performance on each deliverable of the project. The percentages for each area are provided in

Table 1.

Table 1: Project Grading

Category	Grade %	Time Allocation	Description	Type of Deliverable
EDC1: Team Enrollment	5	0.25 hours	Based on the teams created in-class, enroll as a Group in Blackboard	Team
EDC2: Team Agreement	10	1 hour	Team Agreement document	Team
EDC3: Gantt Chart	10	1-2 hours	Gantt chart outlining project deliverables and timeline	Team
EDC4: Meeting Notes	15	3 hours	Completed notes outlining team info, meeting agenda, discussions, individual ideas, and/or experimental results (data)	Team
EDC5: Performance	15	20 minutes	Score as outlined in Grading and Evaluation	Team
EDC6: Oral Presentation	15	5-10 hours	Technical presentation that is neat, well-organized, informative, and professional	Team: Assigned Sections for Individuals
EDC7: Final Technical Report	20	10-20 hours	Technical report following course and assignment guidelines	Team: Assigned Sections for Individuals
EDC8: Peer Review/ Participation	10	1-2 hours every day	Peer review will be performed at end	Individual

6. DELIVERABLES

All deliverables are described in detail in a separate document. Please make sure you submit a copy online in Blackboard.

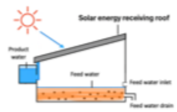
- EDC 1- Team Enrollment
- EDC 2- Team Agreement
- EDC 3- Gantt Chart
- EDC 4- Meeting Notes #1, #2, #3
- EDC 5- Performance- Testing of Your Final Product (in-class)
- EDC 6- Oral Presentation (in-class; also upload slides to Blackboard)
- EDC 7- Technical Report
- EDC8- Peer Review/Participation – Teammate evaluations (individual)

Appendix B2. Overview of the Engineering Design Challenge (EDC) - Solar Distillation

Engineering Design Challenge Project: Solar Distillation

1. OVERVIEW

Design, build, and test a solar distillation system that can heat and purify water using solar energy simulated by a single infrared light source. During testing, minimum 500 mL of water will be supplied and maintained within the system's reservoir throughout the 5-minute operation period. The goal is to safely heat the water and collect distilled water through condensation.



Three components for your system:

1. **Feed Water Reservoir Basin (inside) and Feed Water Supplier (outside)**
   - The feed water reservoir basin includes an inlet for external water supply and a drain for removing residual water after testing.
   - The reservoir basin must maintain at least 500 mL of water level in the distillation chamber using a passive flow-control mechanism (e.g., gravity feed, float valve, or capillary wick).
   - Feed water should be supplied continuously from an external feed water supplier, so that as the water level in the inside feed water reservoir basin drops, water from the feed water supplier flows into the basin to keep the level steady, enabling ongoing evaporation and the production of clean water.
2. **Solar Energy Receiving Roof**
   - Designed to absorb and transfer heat from the infrared lamp to the water below.
   - Should be angled to promote condensation runoff toward the collection outlet.
3. **Distilled Water Collection Area**
   - Collects condensed (purified) water from the roof and channels it through an outlet line to an external collection container.

The water should be able to enter the system from an external source and stay in the reservoir without leaking during solar distillation. A passive water supply system must keep the water level steady in the distillation chamber. Ensure there are no leaks during operation. The distilled water will be collected and directed outside the system via the water flow line. No electrical or powered components (pumps, motors, or fans) are permitted. Material costs cannot exceed $20.00. All purchases must be documented, and receipts must be included in the appendix of the final technical report. The device may not use more than 1 liter of water.

2. RULES

1. The device must fit in a 30 cm (width) by 30 cm (length) space, with no specific height limit; however, a high ceiling is not effective for warming up water in the reservoir.
2. One infrared light will be used to model the sun, placed at least 30 cm (perpendicular to the roof surface) from the apparatus. The distance will be measured from the end of the bulb to the closest part of the collector.

3. The build must include all three components identified above.
4. The device must hold at least 500 mL of water without leaking.
5. A passive water supply system must keep the water level steady in the distillation chamber.
6. The distilled water collection area and its outlet must be placed in the system.
7. The monetary cost for the team must be less than $20.00. Recyclable materials are encouraged. The use of recycled materials will not add to the total cost of your design, but a minimum cost of $5.00 will be used in efficiency calculations.
8. No additional power sources are permitted.
9. Material costs must be documented.

3. TESTING

1. The final design will be tested by placing the build 30 cm from the light source.
2. Students will be able to initially adjust the light source relative to the solar heater device.
3. Room-temperature water will be given to the students. The initial temperature of the solar distillation chamber (air temperature) and water in the reservoir will be measured and recorded.
4. The water must be quickly poured into the system reservoir through the inlet line. Once the water is added, the timer will start.
5. The water heater will have up to 5 minutes to heat the water. Students may signal the timekeeper if they wish to stop the timer before 5 minutes.
6. At the end of 5 minutes (or when the students signal the timekeeper), the distillation chamber temperature (air temperature) and water in the reservoir will be measured and recorded.
7. During the test, students are not allowed to control the solar distillation system. Water may not be poured multiple times through the distillation system.

3.1. REQUIREMENTS

- ☐ Technical report submitted on time; price list and inventory submitted at time of test
- ☐ Material costs $20.00 or under
- ☐ Device fits in a 30 cm x 30 cm area
- ☐ Build includes three components described above.
- ☐ Device is able to hold at least 500 mililiter of water and does not leak

– 5% for each missing REQUIREMENT & team cannot compete for bonus points

3.2. EFFICIENCY RATIO

$$Efficiency = 0.4\left[\frac{\Delta t_{air}}{10°C}\right] + 0.4\left[\frac{\Delta t_{water}}{2°C}\right] + 0.2\left[\frac{\$20}{Cost}\right]$$

Note: The minimum cost allowed is $5.00 (i.e. even if all your materials were free, you must enter $5.00 in the formula above when calculating the efficiency ratio).

4. GRADING AND EVALUATION

Your grade for the project is based on a combination of your design, how well you do in the demonstration and project, the final technical report, and the oral presentation of your work.

Design Scoring

Activity	Points
Increased Air Temperature	
• $\Delta t_{air} \geq$ 10.0°C	100%
• 3°C$\leq \Delta t_{air} <$ 10.0°C	90%
• $\Delta t_{air} <$ 3.0°C	85%
Efficiency Bonus Points(from all 3 sections of ENGR 1201)	
• 1st Place	+10%
• 2nd Place	+5%
• 3rd Place	+3%

– 5 % for each missing REQUIREMENT & team cannot compete for bonus points

Your model must adhere to the REQUIREMENTS and will be penalized if violated (see REQUIREMENTS section). The model must be professional looking, well-planned, and well-executed.

5. FINAL PROJECT GRADE

Your grade for the project is based on your performance on each deliverable of the project. The percentages for each area are provided in

Table 1.

Table 1: Project Grading

Category	Grade %	Time Allocation	Description	Type of Deliverable
EDC1: Team Enrollment	5	0.25 hours	Based on the teams created in-class, enroll as a Group in Blackboard	Team
EDC2: Team Agreement	10	1 hour	Team Agreement document	Team
EDC3: Gantt Chart	10	1-2 hours	Gantt chart outlining project deliverables and timeline	Team
EDC4: Meeting Notes	15	3 hours	Completed notes outlining team info, meeting agenda, discussions, individual ideas, and/or experimental results (data)	Team
EDC5: Performance	15	20 minutes	Score as outlined in Grading and Evaluation	Team
EDC6: Oral Presentation	15	5-10 hours	Technical presentation that is neat, well-organized, informative, and professional	Team: Assigned Sections for Individuals
EDC7: Final Technical Report	20	10-20 hours	Technical report following course and assignment guidelines	Team: Assigned Sections for Individuals
EDC8: Peer Review/ Participation	10	1-2 hr/day	Peer review will be performed at end	Individual

6. DELIVERABLES

All deliverables are described in detail in a separate document. Please make sure you submit a copy online in Blackboard.

- EDC 1- Team Enrollment
- EDC 2- Team Agreement
- EDC 3- Gantt Chart
- EDC 4- Meeting Notes #1, #2, #3
- EDC 5- Performance- Testing of Your Final Product (in-class)
- EDC 6- Oral Presentation (in-class; also upload slides to Blackboard)
- EDC 7- Technical Report
- EDC 8- Peer Review/Participation – Teammate evaluations (individual)

Appendix B3. Overview of the Engineering Design Challenge (EDC) - Cardboard Crane

Engineering Design Challenge Project: Cardboard Crane

1. OVERVIEW

Design, build, and test a crane with mass and material restrictions. The lifting mechanism of the crane must be powered by a motor (consider the use of a DC motor), while the rotation of the crane can be provided by either manual work or by motor. During the test phase, the crane will be positioned on the corner of a 60 cm high table and anchored with C-clamps. The crane must be able to lift a 550 g load at least 30 cm off the ground (initially 60 cm below the base of the crane on the floor), rotate 90-degrees, and set the load on a platform. The crane must include these 4 component parts:

- Mechanism to engage and lift mass bucket (i.e. hook)
- Base to hold crane to table
- Motorized lifting mechanism utilizing a switch (9V battery provided and included in self-weight; teams may provide alternate power source- included in self-weight)
- Swivel mechanism, either manually powered or using an additional motorized component

The operator can touch the crane only at handles, levers, cranks, or switches designed to operate the crane. The operator may not touch strings or cables used in the crane. Once lifted, the crane must be able to hold the mass in the bucket without the operator touching any part of the crane.

2. RULES

1. The device must fit in a 60 cm x 60 cm x 60 cm crate.
2. Two C-type clamps will be used to attach the crane to the table.
3. The total mass of the crane must not exceed 1100 grams.
4. Crane must have a mechanism (e.g., hook) to engage and pick up the mass bucket. You cannot directly tie a string to the weight bucket.
5. During lifting, the operator must use a motorized component connected to a switch to lift the bucket from the ground. The operator may use manual work to rotate the crane.
6. During the maximum load test, the crane must be able to hold the mass in the bucket without the operator touching any part of the crane.
7. During truck loading, the operator can touch the crane only at handles/levers/cranks/switches designed to operate the crane. The operator may not touch strings/cables used in crane.
8. With the exception of paper clips, motor(s), electric wires and switches, all materials must be sustainable and natural. Allowable materials are:

Allowable Material	*Unit*	*Cost per Unit*
Paper, paperboard, or corrugated cardboard	grams	$0.02
White glue*	grams	$0.02
Paper masking tape	grams	$0.02
Natural Fiber String †	grams	$0.02
Motor, electric wires, switches, power source	grams	$0.02
Standard 1" Metal Paper Clips	each	$0.50

* Elmers or similar white glue
† Cotton, jute or other natural fiber, no polymers such as polyester or nylon

3. TESTING

1. Final design will be tested by placing it on the provided table and performing two tests.
   a. Using a motorized component, lift a mass of 550 grams from the floor to the height of 30 cm, rotate the mass 90 degrees and set the mass down on the designated platform. Clamps may not be adjusted during testing.
   b. Raise bucket to a height of 30 cm, lock raising mechanism, load bucket to failure.
2. The computed cost of the crane, mass of the crane, the maximum mass held, and the time required to lift the initial mass required distance will be recorded and used to evaluate designs (see $Effciency = 0.4\left[\frac{Failure\ Load\ (kg)}{Crane\ Mass\ (kg)}\right] + 0.4\left[\frac{6s}{Time}\right] + 0.2\left[\frac{\$20}{Cost}\right]$ Equation 1).
3. Calculate: maximum bending moment in the crane boom, the raise velocity of the crane, maximum tension in the string, and strength to weight ratio.
4. Compute the cost of your crane using the material costs listed in the allowable materials table.

3.1. REQUIREMENTS

- ☐ Fits in 60 cm x 60 cm x 60 cm space
- ☐ Only allowable materials used
- ☐ Total mass of crane less than 1100g
- ☐ Crane includes carrying mechanism (e.g., hook)
- ☐ Crane includes motorized lifting component
- ☐ Crane operates within rules
- ☐ Crane completes lift and rotate test

– 5% for each discrepancy & cannot compete for bonus points

3.1. EFFICIENCY RATIO

$$Effciency = 0.4\left[\frac{Failure\ Load\ (kg)}{Crane\ Mass\ (kg)}\right] + 0.4\left[\frac{6s}{Time}\right] + 0.2\left[\frac{\$20}{Cost}\right] \qquad \textit{Equation 1}$$

4. GRADING AND EVALUATION

Your grade for the project is based on a combination of your design, how well you do in the demonstration and project, the final technical report, and the oral presentation of your work.

Design Scoring

Activity	Points
Base Score	
• Max load ≥ 4000 g	100%
• 2000 g ≤ Max Load < 4000 g	90%
• Max load < 2000 g	85%
Bonus Points (places based on all 3 sections of ENGR 1201)	
• 1st Place	+10%
• 2nd Place	+5%
• 3rd Place	+3%
• Motorized Swivel Mechanism	+10%

5. FINAL PROJECT GRADE

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- EDC 7- Technical Report
- EDC8- Peer Review/Participation – Teammate evaluations (individual)