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Inspiration Station for First-Year Engineering Projects

Dr. Fethiye Ozis, Carnegie Mellon University

Dr. Fethiye Ozis is an Assistant Teaching Professor in the civil and environmental engineering department at Carnegie Mellon University. Dr. Ozis holds a B.S. in environmental engineering from the Middle East Technical University, Ankara, Turkey and M.S. and Ph.D. degrees from the University of Southern California. Dr. Ozis is a licensed Professional Engineer, Environmental, in Arizona. Before joining CMU, Dr. Ozis was a faculty member at Northern Arizona University.

Dr. Kelly Salyards P.E., Bucknell University

Dr. Salyards is an Associate Professor in the Department of Civil and Environmental Engineering at Bushnell University. She has BAE, MAE, and PhD degrees in Architectural Engineering from The Pennsylvania State University. She joined Bushnell in 2007 and

Dr. David A. Saftner, University of Minnesota Duluth

David Saftner is an Associate Professor at the University of Minnesota Duluth. He received a BS in Civil Engineering from the United States Military Academy and MS and Ph.D. in Civil Engineering from the University of Michigan.

Dr. Tanya Kunberger, Florida Gulf Coast University

Inspiration Station for First Year Engineering Projects

Abstract
This evidence-based practice paper provides engineering educators teaching first-year introductory courses, who are new or looking to update their courses, inspiration with diverse project ideas. The active learning via project-based, activity-based, and service-based courses within the first-year engineering curriculum has proven effective for students not only to become more engaged and motivated but also to experience increased learning and retention. Generally, first-year engineering courses are meant to create student experiences that are meaningful, open-ended, and hands-on in addition to being an introduction to working and communicating effectively within teams. Whether one is an experienced educator or not, looking for project ideas to adapt, or developing projects that are of appropriate scope and value on your own or in collaboration with colleagues is challenging and time consuming. Although there is an abundance of peer reviewed work studying first-year projects or activities of many kinds, a composite repertoire for first year engineering project ideas is less available. The existing literature focuses on the tied research questions more than how the project is implemented for straightforward transfer to another classroom setting. Limited inventories, where individual ideas and projects are listed, exist; however, finding the project that fits one's needs again requires choosing the right keywords to start reading through multiple posts, folders and files, and is not straightforward.

In this study, the authors surveyed faculty teaching introductory courses in engineering to explore the range of projects already developed, the basic details of the projects, and topics addressed in each. The online survey was utilized to collect faculty members' teaching approaches, preparation, activities, and materials needed, as well as self-reflection. Data analysis categorized first-year engineering projects (N=32) by the project outcomes, themes, extent within the course coverage, grading system, institutions' educational model, and the projects' inclusivity of other power/holistic skills. There were common features among the first-year introductory engineering courses including the engineering design process, teamwork, and professional communication. Additionally, the authors identified supplemental themes such as prototyping (P), sustainability (S), project management and economics (PM), ethics (E), and the inclusion of the Diversity, Equity, Inclusion and Justice (DEIJ) issues.

Introduction/Motivation
The purpose of this study is to explore and document types of projects implemented in first-year introductory engineering courses. Many engineering courses have well defined content and do not greatly vary from university to university. For example, many required, discipline-specific, junior-level civil engineering courses focus on the content covered in that discipline on the Fundamentals of Engineering (FE) exam. Additionally, engineering faculty preparation often comes in their specialty area and not general or introductory engineering. These, among other factors, make designing an effective introduction to engineering courses challenging. Landis [1] recommends five course objectives for introduction to engineering courses: community building, professional development, academic development, personal development and orientation.

Design projects apply to many of these. In community building, the team aspects of numerous projects help students develop professional skills and build a support network for their college experience. Teaching the engineering design process and engineering's role in a better society is excellent professional development. Productive interactions with peers and faculty, as well as learning to prioritize important aspects of a project, develop students academically. Interacting with teammates and managing both personal and professional responsibilities aid in personal development. Depending on how a project is structured, students may gain insight into department, college, and/or university structure through purchasing equipment, using library/facility resources, and other interactions, contributing to their orientation to college life. Additionally, and significantly, design projects are fun and an outstanding advertisement to the wonders of the engineering profession. However, choosing a good design project to accompany an introduction to engineering course is not straightforward or simple.

The authors initiated this study to characterize existing introductory engineering projects and provide a catalog for instructors to choose a project that fits the goals of their course. This paper will first describe previous literature on first year introduction to engineering courses and their projects. A description of the survey used to collect information about introduction to engineering design courses follows. Results from the survey are described, as well as an analysis simplifying choice of a project for instructors either new to teaching introductory courses or those wishing to find a project that better suits their goals.

Background

Range of 1st year courses: general to disciplinary, content

Even though many universities require a first-year course as an introduction to engineering, the variability of the focus, content, pedagogy, course outcomes, and logistics is significant. Courses range from discipline-specific within a program to more general, common across all disciplines within engineering. The content of the courses range in both their technical skills, including traditional engineering design, numerical computing and coding, computer aided design, or fabrication skills, and their professional skills, including written and oral communication, teamwork, and conflict resolution. The pedagogical strategies also vary, often a result of structural logistics of the class size and delivery mode.

Despite the wide range of differences, one prevalent pedagogical approach involves some version of a project to reflect the open-ended, real-world, team-based problems that engineers will face after graduation. Research has shown that early exposure to these types of problems yields an increase in self-efficacy, intellectual development, and retention of underrepresented minorities and women in undergraduate engineering [2]. The project topic and scope are highly dependent on the structural logistics of the course but can often be modified for other scenarios. Cropley [3] suggested providing projects where new problems are matched with new solutions to initiate *creativity* in problem-solving, which is deemed important for engineering education. The selection and development of suitable projects and relevant assignments for first-year students is time consuming and can be daunting for new faculty or faculty new to a first-year course.

Projects in first year engineering courses

The authors performed a brief review of the literature to explore projects utilized in first-year courses and the results where sufficient project details were provided was limited. The most prevalent location for publications highlighting the first-year project details is the proceedings of the annual American Society of Engineering Education (ASEE) conference and KEEN cards (engineeringunleashed.com/card).

Projects ranged from solar-powered food dehydrators [4], re-engineering a mini-drone [5], reverse engineering of a simple household appliance or medical device [6], energy efficiency assessment of windows [7], or more general problem prompts such as food insecurity or the opioid epidemic [8].

Methods

In order to gather project information from a range of programs, the authors developed an electronic survey (with the study designated exempt and approved by Bucknell University's IRB #2223-051, which included both multiple choice and open-ended responses. The first set of questions asked respondents general information about their institution and first-year courses (e.g., how the calendar is divided, how many hours a week does the course meet, and does the course include a project). The second set of questions related to the logistics of the course project, including questions such as which discipline(s) would the project classify as, what theme (if any) does the project follow, and what portion of the class and grade are affiliated with the project. The next set of questions allowed users to provide an open-ended project description, information on how projects were completed (e.g., individually or in teams, team size, etc.), and details on the project and project deliverables. Questions on the project relation to course objectives, ABET outcomes, and other technical and professional skills rounded out the survey. Participants were allowed to opt-out at any time, could decline to answer any question(s), and could choose to attach additional information / resources associated with their projects at the end of the survey. The survey request was sent to multiple interest groups including ASEE divisions and KEEN partner institutions and was administered through Qualtrics.

At the conclusion of survey collection, the raw data was exported into Excel for thematic analysis. The authors identified complete versus incomplete submissions and analyzed results for thematic traits as detailed in the results section.

Results/Analysis

As described in the Introduction/Motivation section, projects provide numerous benefits to student learning, including community building, professional development, academic development, personal development, and providing an orientation to college resources. As several respondents to the authors' survey indicated that their first-year introduction to engineering course does not include a project, there is a demonstrated need to compile current first-year, introductory design projects.

The online Qualtrics survey received 44 responses. Two respondents indicated that they didn't have a first-year introductory engineering course and ten respondents opted out before completing the survey. A total of 32 respondents answered all the questions on the survey. Only the complete surveys were used for the data analysis. Almost all the projects reported including the engineering design process, teamwork, and technical communication. Additionally, five other common themes emerged: prototyping (P), sustainability (S), project management and economics (PM), ethics (E), and diversity, equity, inclusion, and justice (DEIJ). The results of the thematic analysis are presented in Figure 1. The most common attributes represented with larger circles include prototyping, project management/economics, and sustainability. Many projects incorporated several attributes, and the most common intersections are depicted here.

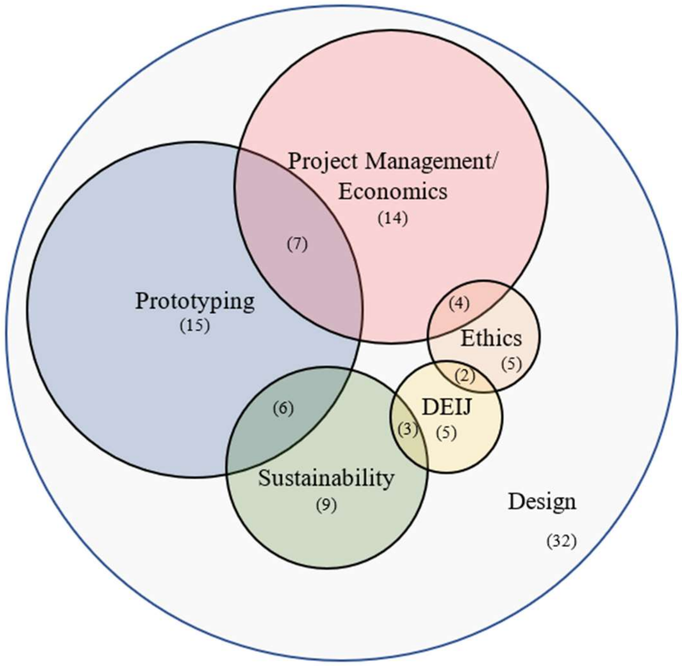

Figure 1: Distribution of project attributes. Number under the attribute indicates the number of projects reflecting that attribute with respective bubble size. Number at intersection indicates number of projects that indicated at least those two attributes. Note: All 3+ attribute combinations are not reflected here, but the most common intersections are included.

Out of the respondents (N=32), 28 had semesters (90%), and three had a quarter system (10%). All responses had a first-year introduction engineering course. The introductory courses' contact hours ranged from 1 to 6 hours. Five respondents recorded 1 hour, three respondents recorded 2 hours, eight respondents recorded 3 hours, five respondents recorded 4 hours, and three respondents recorded 6 hours. Out of 32, 20 (62.5%) respondents classified their course as a general engineering course, and 12 (37.5%) classified it as discipline specific.

The survey also asked if the first-year project involved any special requirements, such as a partnership, facilities, or cost. It was interesting to note, as shown in Figure 2, that most projects did not identify any special requirements (23 of 32). This affirms that most of the project ideas presented herein could be utilized without additional external support.

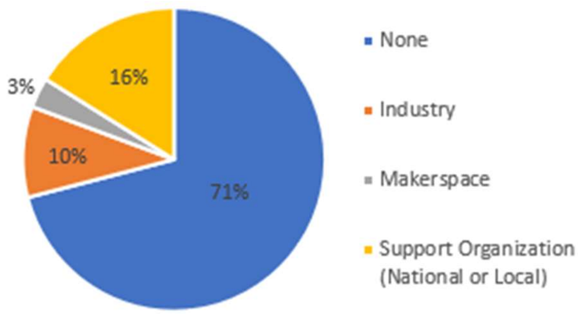

Figure 2: Special requirements identified for projects

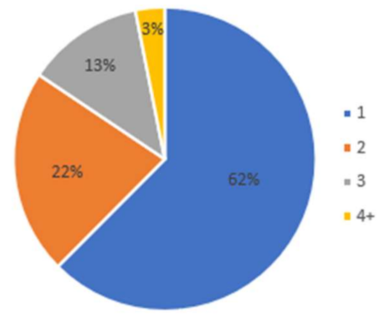

Figure 3: Number of projects in first-year engineering course

The survey also asked how many projects were integrated into the first-year engineering course. Most responses (20 of 32, 62.5%) as shown in Figure 3, indicated that their course involved a single project. If the course involved more than one project (12 of 32), the respondent was asked to provide information about the project that they are most familiar with or what they would consider to be the most successful project. Seven (22%) respondents had two design projects, four (12.5%) respondents had three design projects, and one (3%) respondent had 4 design projects during their course. Table 1 presents a summary of the complete responses to the survey. We named each project and categorized them according to the description, emphasis of the projects, and special requirements.

Table 1: The project ideas, including project titles, codes (themes) and special requirements.

1- Sustainable Rural Development Call for Proposals Codes: S, P Special Requirements: None	Students develop site planning, power systems and assistive systems for various needs for a rural community. They conduct a full design process (framing, ideation, prototyping) in a team of 4-6 students over ~6 weeks. The options include greenhouse control system, natural hazard protection, automated crop harvester, and etc.
2 - Engineering for People Design Challenge Codes: None Special Requirements: EWB-UK	Students work on a project they choose under Engineers Without Borders-UK's the Engineering for People Design Challenge, which employs a project-based learning approach through a community based real-world problem.
3 - Popsicle Truss Bridge Codes: PM Special Requirements: None	Students are tasked to create truss bridges paying attention to the economic analysis of the bridge design. 3 reports and oral presentations. Supplies covered from course fees.
4 - Interdisciplinary Client Based Codes: P Special Requirements: Industry	Students choose from client-based projects, which can be categorized into animals, design for disability, environment, human, infrastructure, and medical. For example, a rhino hay feeder for a Zoo to an alert device for elderly individuals who are hard of hearing.

5 - Solar Oven Design Codes: None Special Requirements: Industry	Students start with the approaches to designing a solar oven. They then look at a modeling approach to [model temperature in] a solar oven, finishing with two design - build - test sequences.
6 - General Engineering Design Codes: P, PM Special Requirements: Industry	Groups of students go through problem definition to concept development, iteration, and final presentation to industry partners, with 15+ milestones along the way. Team of 3-5 students.
7 - Introduction to Design Codes: PM, E Special Requirements: EWB	Students pick problems from the Engineers Without Borders platform featuring several areas to choose from. The approach is project-based learning through a community based real-world problem.
8 -Fabricate a Gear Train Codes: P, PM, E, DEIJ Special Requirements: None	Students design and fabricate a geared system to pull weights fast with a number of constraints. Students are asked to use the makerspace of the institution for the fabrication. They can use 3D printing and wood equipment.
9 - Hydraulic Assembly for Capturing Elements Codes: P, E Special Requirements: None	Students design a hydraulic assembly with only the provided materials to compete in the game of battle ball. The objective is to capture the most ping pong balls within a square arena. After building, the class competes in a battle ball tournament.
10 - STEM Educational Activity Design Codes: P Special Requirements: None	Students design a STEM activity for 5-6th grade students that illustrates at least one of the 14 Grand Challenges for Engineers identified by the National Academy of Engineers.
11 - Nature-inspired Simulation Codes: * Special Requirements: None	Students design a simulation in Matlab for an interesting phenomenon in nature that could be the inspiration for an innovative new product.
12 - Soccer-playing Robot Codes: P, PM Special Requirements: None	Students design a robot to play a modified version of soccer. Develop a prototype that meets design goals, wins competition, is cost effective, and is aesthetically pleasing.
13 - Grand Challenges Codes: P, PM Special Requirements: NAE	Students use technology to pitch a design solution to solve a customer's need, related to NAE's 14 Grand Challenges for Engineers.
14 - Living on Mars Codes: None Special Requirements: None	Students design a module of an outpost on Mars to support human occupancy. A competition to create the first permanent outpost on the Red Planet to support at least 25 people that will last at least 15 years and be self-reliant during 26-month intervals.
15 - Transforming Transportation Codes: P, S, PM, E, DEIJ Special Requirements: None	Students design a solution to address a compelling problem in transportation. Develop a prototype to demonstrate your design.

16 - Flood Control for Local Creek Codes: PM, E Special Requirements: None	Students reduce flood flows by storing floodwater in the surrounding landscape rather than in reservoirs. As a result, numerous culverts near the creek would need to be redesigned. Students tackle this design using software taught in the course.
17 - Land Use Proposal Codes: S, PM, DEIJ Special Requirements: None	Groups of students choose an on-campus problem involving land use. Examples include increasing recycling & improving on-campus transportation. They solve the problem using sustainability criteria identified by a university task force.
18 - Data-driven Energy Saving Plan Codes: None Special Requirements: None	Students fabricate temperature sensors and monitor data near windows on campus. Their experimental design and data drive recommendations for window replacement prioritization on campus.
19 - Community RFP's Codes: P, S, PM Special Requirements: None	Students respond to a request for proposals (RFP) from local stakeholders. While the topics change each semester, student teams are expected to follow the engineering design process and present solutions to their stakeholders.
20 - Energy Audit Codes: PM Special Requirements: Local Orgs	Students redesign energy systems for a local church.
21 - Biomedical Device Redesign Codes: P, PM, DEIJ Special Requirements: None	Students design improvements to an inexpensive biomedical engineering device of their choice. Examples include urine specimen cups and paper gowns. Students learn the engineering design process by reverse engineering and redesigning these essential but inexpensive devices.
22 - Engineering for People Design Challenge Codes: S, DEIJ Special Requirements: EWB-UK	Students participate in the international Engineering for People design challenge hosted by EWB-UK including a year-end competition. They provide an extensive design brief for a community at yearly changing communities in the world. A partner NGO provides significant cultural aspects to go along with the engineering challenges.
23 - 3D Printable Wearable Sensor Codes: P, S Special Requirements: Makerspace	Students develop a customized wearable sensor tied to a project of their choice as part of a Making course. Integrates KEEN's Curiosity, Connections, and Creating Value, hand sketches, CAD-drawings, 3-D printing, and assembly as well as final reports and presentations into the semester project.
24 - Digital Twin Creation Codes: None Special Requirements: None	Civil students use REVIT to create a digital twin of their building from professional engineering drawings. Mechanical students dissect a pre-approved product and use Fusion 360 to create a digital twin with full animation and tolerance analysis.
25 - Refugee Dwelling Improvement Codes: None Special Requirements: None	Students design an improved component of a refugee dwelling unit.

26 - Conceptual Campus Design Codes: *, P Special Requirements: None	Students individually complete a conceptual redesign of a campus project, for example a redesign of a street on campus to a pedestrian mall. A primary goal is to identify the key characteristics and challenges of civil infrastructure systems.
27 - Model Construction and Testing Codes: PM Special Requirements: None	Students work in teams to complete a cardboard crane, water clock, or solar water heater that undergoes model testing in a competition.
28 - Interdisciplinary Design Project Codes: P, S Special Requirements: None	Teams engage in interdisciplinary design projects that follow the cycle of design from ideation, information gathering, prototyping, implementation, and testing and evaluation. Projects have ranged from passive and active solar projects, a tiny house, and recreational trail surface evaluation and improvement.
29 - Build-a-Bridge Codes: PM Special Requirements: None	Students design, build and test bridges constructed from wood members (paint sticks), wood squares (gusset plates), nuts, and bolts. The bridges were designed to support a total weight of 290 Lbs. The goal of the project was to design and build a bridge that balances safety, economy, and aesthetics. The economy of the bridge was evaluated by weighing the total materials used in the construction. Bridge safety was verified by in-class testing, and aesthetics were judged by peers and the faculty.
30 - Engineering an Outdoor Classroom Codes: P, S Special Requirements: None	Students design a feature that could benefit the anticipated outdoor classroom location on campus as being designed for the end-user from Humanities disciplines. Designs encompass anything from shelter from the elements, pervious ground covering, natural barriers to limit distractions, rainwater collection system, solar panel array.
31 - Product Archeology Codes: S Special Requirements: None	Teams complete a backwards design analysis on an existing engineered product, identify customer requirements, design specifications, and manufacturing processes to understand the decisions that led to the product development. Focus includes societal, economic, global, and /or environmental impacts.
32 - K'Nex Bridge Codes: None Special Requirements: None	Students bridge a gap using a bridge built of K'Nex. The bridge needs to hold either a heavy weight in the middle of the bridge or a medium weight at the one third points of the bridge, depending on the results of a coin flip. The bridge is judged based on aesthetics, weight, and ability to hold the weight.

*In corresponding projects, the respondents said "No" to the following question: "Do you teach the Engineering Design Process?"

Prototyping

As shown in Table 2, within our data, the total number of projects emphasizing prototyping was 15. All these courses were taught over a semester. Two of 15 needed industry partners, one project (#13) used NAE as a partner, one needed (#23) makerspace and eleven needed no special requirements. Eighty percent of the prototype projects (12/15) had an added component, the projects were joined with project management and economics (n=7), sustainability (n=6), DEIJ (n=3) and ethics (n=3). Four out of 15 (27%) projects were discipline specific, the rest were in the general engineering category. Two of these discipline specific projects were in the mechanical engineering (project #8 and #9), and project #21 was in the biomedical engineering, and project #23 was in chemical engineering field. Thirteen faculty members indicated that the prototype project they assigned provides a truly open-ended design experience with many acceptable solutions. Two (projects #8 and #12) indicated although their projects are somewhat directed such that less than three solutions are possible. All prototype engineering projects were team projects. Teams were composed of three students for two (17%) projects, four to five students for the rest of the prototype projects. The maximum number of teams or projects per instructor reported was 20, while it ranged anywhere between three projects or teams per instructor to 20 per instructor, five to six projects or teams per instructor was reported as being the most common.

Three projects (# 4, #6, and #19) were used in their Department's ABET assessment for ABET Outcome 2. STEM Educational Activity Design and Grand Challenges, projects #10 and #13, respectively, were used to assess ABET Outcome 5. Lastly, 3D Printable Wearable Sensor, project #23, was used for ABET Outcome 1.

Table 2: Prototyping Projects.

Project # - Project Title	**Project # - Project Title**
1 - Request for Proposals	13 - Grand Challenges
4 - Interdisciplinary Client Based	15 - Transforming Transportation
6 - General Engineering Design Project	19 - Community RFP's
8 - Design Geared System	21- Biomedical Device Redesign
9 - Hydraulic Assembly for Capturing Elements	23 - 3D Printable Wearable Sensor
10 - STEM Educational Activity Design	26 - Conceptual Campus Design
12 - Soccer Playing Robot	28 - Interdisciplinary Design Project
	30 - Engineering an Outdoor Classroom

Sustainability

In Table 3, of the 32 projects described through our survey, nine projects specifically identified sustainability as an additional educational component of the project. Most of the projects were employed in a general engineering course, but all had a flavor of civil engineering or land development. None of the projects required an industry sponsor but some required a makerspace, and one had a supporting organization (Engineers Without Borders). All but one of the projects specifically mentioned that the engineering design process is taught within the course and employed for the project. Six of the nine projects also had a focus on prototyping and four had an additional focus on project management or diversity, equity, inclusion, and justice. All projects were completed in teams of 3-5 students.

Table 3: Sustainability Projects.

Project # - Project Title	**Project # - Project Title**
1 - Sustainable Rural Development Call for Proposals	22 - Engineering for People Design Challenge
15 - Transforming Transportation	23 - 3-D Printed Wearable Sensor
17 - Land Use Proposal	28 - Interdisciplinary Design Project
19 - Community RFP’s	30 - Engineering an Outdoor Classroom
	31 - Product Archeology

Project Management/Economics

As shown in Table 4, fourteen projects in this study focused on project management and/or engineering economics. All except the Energy Audit (architectural engineering, project #20) was used in a general introduction to engineering course and was not discipline-specific. Only the Introduction to Design, project #7, was used in the quarter system, the rest of the projects were used as semester projects. In addition to occupying the project management and economics category, five projects also included prototyping, three included sustainability components, three included ethics, and three included a DEIJ component.

Only the Energy Audit was an individual project. The rest of the projects were team-based with 3 to 5 students forming a team. Instructors were responsible for 3 to 20 teams, depending on the current project design. All these projects specifically included instruction on the engineering design process. Only the General Engineering Design Project, project #6, worked with external partners. Deliverables included written reports, oral presentations, and, for the five projects that included prototyping, a prototype of the design. Two projects, the General Engineering Design project and Community RPP’s, projects #6 and #19, respectively, were used in their Department’s ABET assessment for ABET Outcome 2. The Energy Audit and Product Archeology, projects #20 and #31, respectively, were used to assess Outcome 3 and the Grand Challenges, project #13, was used to assess ABET Outcome 5.

Table 4. Project Management & Engineering Economics Projects.

Project # - Project Title	Project # - Project Title
3 - Popsicle Truss Bridge	16 - Flood Control for Local Creek
6 - General Engineering Design Project	17 - Land Use Proposal
7 - Introduction to Design	19 - Community RFP's
8 - Fabricate a Gear Train	20 - Energy Audit
12 - Soccer Playing Robot	21 - Biomedical Device Redesign
13 - Grand Challenges	27 - Model Construction and Testing
15 - Transforming Transportation	29 - Build-a-Bridge

Ethics

As summarized in Table 5, ethics was explicitly identified as an emphasized power / holistic skill for five of the 32 projects. Two of these projects, Fabricate a Gear Train (#8) and Transforming Transportation (#15) integrated all (#15) or all but one (#8) of the identified themes, with each of these classes dedicating roughly half (7 or 8 weeks) of the course to these projects.

Table 5. Ethics Projects.

Project # - Project Title	Project # - Project Title
7 - Introduction to Design	9 - Hydraulic Assembly for Capturing Elements
8 - Fabricate a Gear Train	15 - Transforming Transportation
	16 - Flood Control for Local Creek

DEIJ

Five projects, summarized in Table 6, also identified DEIJ concepts as an additional area of emphasis. While these projects were included in both general and discipline-specific courses, most courses included disciplines such as biomedical, civil, environmental, and mechanical engineering.

Table 6. Diversity, Equity, Inclusion and Justice Projects.

Project # - Project Title	Project # - Project Title
8 - Fabricate a Gear Train	17 - Land Use Proposal
15 - Transforming Transportation	21 - Biomedical Device Redesign
	22 - Engineering for People Design Challenge

Time Analysis
In addition to presenting the projects as organized above, the projects were analyzed for the amount of class time devoted to the project, the portion of the course grade attributed to the project, and the deliverables expected for the project. The class time devoted to the project was calculated based on the responses about calendar division (semester, quarter, etc.), number of contact hours in the first-year engineering course, and how many weeks of the course were devoted to the project. A ratio, shown in Figure 2, was then determined between the class time devoted to the project and the total class time.

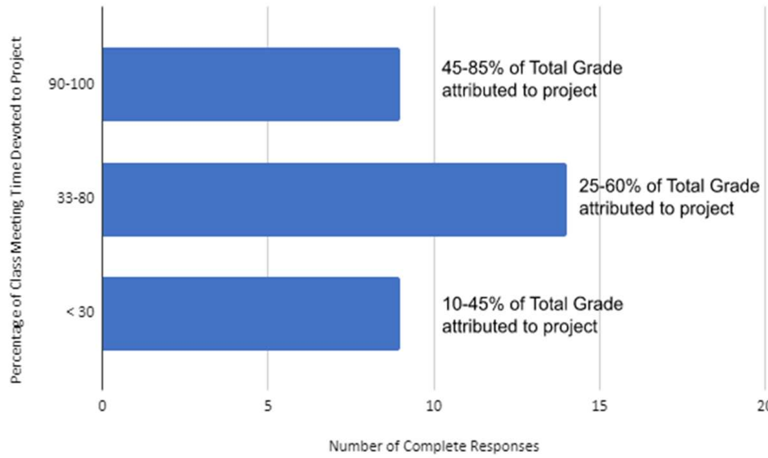

Figure 2: Percentage of total class time (e.g. number of hours on project / total number of hours in course) devoted to the project and the related percentage of course grade attributed to that project

When more than 90% of course meeting time was devoted to the project (9/32 responses), the majority of the course grade, 45-85%, was attributed to the project as can be seen in Figure 2. Many of the respondents (14/32) indicated that between 33-80% of the course meeting time was devoted to the project. The range of the course grade attributed to the project also varied significantly from 25-60%. If less than 30% of class meeting time was devoted to the project, the course grade contribution was also relatively low, ranging from 10-45% (9/32 responses).

The variety of class deliverables also aligned, to some extent, to the percent meeting time. Most (8 of 9) of the projects encompassing 90% or more of the course meeting time had multiple expected deliverables including oral presentations, posters, slide decks, prototypes and/or written reports. Those projects taking 30% or less of the class meeting time most often included only one or two deliverables - although it varied across the type of deliverable. Projects in the middle range included a greater variety in the number of deliverables, with an oral presentation being at least one of the deliverables in 11 of the 14 projects.

Discussions and Future Expansion
When asked how they might apply the project in future semesters, about half of the respondents (18/32 - 56%) indicated they would keep everything as is, with no modifications. Of those who indicated they would make modifications; these fell into logistical and topical areas. Logistical items included the clarification of wording, refinement of rubrics, or changes in the topic (Project #19 which responds to community RFPs). Topical areas that were most often mentioned included conflict management, group dynamics, additional constraints, and design optimization.

Analysis of the results showed that nearly all of the projects included several factors, including the engineering design process, teamwork, and professional communication. Factors such as prototyping, sustainability, project management and economics, ethics and DEIJ issues were also common themes. The tables presented in this section provide a database of potential projects for instructors updating or creating a design project for their introductory course. Additionally, an analysis of time requirements and project deliverables was presented.

Research shows that DEIJ are important aspects of engineering education that impact the experiences and outcomes of students, faculty, and the engineering profession as a whole. In addition, project-based learning can provide numerous benefits for marginalized students in engineering education, including increased engagement, contextualized learning, collaborative opportunities, authentic assessment, enhanced self-efficacy, and exposure to role models and mentors. Among our respondents, only 16% of the projects stated having DEIJ emphasis. Unfortunately, our survey did not collect any details on how those connections between DEIJ and FY projects were made by the survey respondents. By leveraging the power of PBL in teaching practices and projects with a focus on DEIJ, engineering educators can create more inclusive and empowering learning experiences through projects that help all students thrive in their engineering education and future engineering careers by fostering innovation, creativity, and excellence. Creating an inclusive learning environment, ensuring equitable access and success, and promoting diverse representation and perspectives in project-based classes within first year engineering courses are essential for retaining and preparing engineers who are equipped to address the complex and grand challenges of the 21st century.

Conclusion

Coming from civil and environmental engineering backgrounds, the authors initially taught fairly well defined required and elective courses in their technical focus areas. Teaching the introductory course several years into their careers, the authors realized that introductory courses are not nearly as well defined or standard across academic institutions. The challenges of designing the course were compounded by including a design project. The intent of this paper is to simplify the process of selecting a design project for instructors developing or updating an introduction to engineering course.

Following a survey of ASEE Divisions and KEEN partner institutions likely to include members who have taught introduction to engineering courses, a database of 32 design projects was compiled. All projects include common features, such as the engineering design process, teamwork, and professional communication. Additionally, many projects focused on prototyping (P), sustainability (S), project management and economics (PM), ethics (E), and/or Diversity, Equity, Inclusion and Justice (DEIJ) issues. To simplify selection for instructors looking for a project with specific goals, these projects were also cataloged. Given the importance of introductory courses in retention, simplifying the process of designing a great introduction to engineering courses will pay dividends in our profession.

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