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Work in Progress: Integrating Engineering Design Projects into Early Curricular Courses at a Hispanic-serving Institution

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WIP: Integrating Engineering Design Projects into Early Curricular Courses at a Hispanic-serving Institution

Introduction

This Work in Progress paper will describe the recent activities of a continuing NSF sponsored project at the College of Engineering at Texas A&M University-Kingsville (TAMUK) that is centered on increasing the rates of student retention and persistence. Emphasis during the project has especially been placed on minority students as well as others typically underrepresented in STEM related fields. An important focus of the project has been enhancing the courses taken by students early in the engineering curricula [2, 6]. This has included the integration of significant design experiences into early curricular courses [1, 3, 7, 8]. Early in the project, the freshmen introductory engineering courses taught within three departments: Chemical and Natural Gas Engineering (CNEN), Electrical Engineering and Computer Science (EECS), and Mechanical and Industrial Engineering (MIEN) were modified to include a significant, collaborative, hands-on engineering design project [4, 5]. More recently the introductory engineering course for the Civil and Architectural Engineering (CAEN) department has also been updated to include a collaborative design project.

The most recent experiences and results of the first-year focused aspects of the project are reported in the paper. It includes descriptions of the hands-on, collaborative engineering design projects used in the most recent offerings of the augmented introductory engineering courses along with improvements made based on previous course offerings. It also reports the details of a significant increase in the number of students participating in the introductory engineering courses. The results of surveys that measured students' perceptions of their abilities, confidence, and knowledge in general problem-solving tasks which were completed both before and after the introductory engineering courses are reported.

Integration of Design Projects into First-year Courses

First-year engineering students at TAMUK take an introductory engineering course entitled "Engineering as a Career" (GEEN 1201). Departments within the College of Engineering each offer their own section of the GEEN 1201 course specifically designed for their students. As part of an ongoing NSF project, the GEEN 1201 courses for four departments (CNEN, EECS, MIEN, and CAEN) have been augmented to include collaborative hands-on design projects. The remainder of this section describes the design projects that were used in each of the updated GEEN 1201 courses during the fall 2022 semester. Descriptions of the design projects used in previous semesters can be found in [4, 5].

Chemical and Natural Gas Engineering: There were four hands-on design projects offered to student teams in the chemical and natural gas engineering section of GEEN 1201, which involved topics in water purification, solar water pumping, salinity treatment by reverse osmosis, and liquid-liquid extraction. For each project, essential mechanical units were provided and the students were tasked with developing and testing a prototype unit or in a laboratory setting. Because of the limited time allotted to the project during the semester (approximately 6 weeks), the instructor gave the specific problem definition to the students, rather than having the students perform their own problem definition based upon a more generic needs statement.

The objective of the water purification project was to develop a prototype device for on-demand purification of water contaminated with a surrogate organic contaminant (methanol, ethanol, or isopropanol) that could be used in emergency situations. For the solar-powered water pump project the main objective was to develop a prototype system in which a solar PV array could be used to pump water into an elevated city water tank under extended-duration power outage conditions. The objective of the desalination project was to use a lab-scale reverse osmosis (RO) filter to investigate the removal of salt from brackish water (several thousand parts per million salt), to levels that can then meet potability requirements. The liquid-liquid extraction project tasked students to investigate the transfer of a solute such as isopropanol between an oily phase and a water phase through liquid phase contact enhanced by mixing or shaking.

All of the different project topics provided the students with hands-on experience in basic fluids concepts such as flow under gravity force, static head, pressure loss, concentration measurements, and flow through porous media. Pictures and diagrams of typical student-constructed devices are shown in Figure 1. The 2022 offering of this GEEN 1201 course was the fourth year that engineering design projects were utilized for this course.

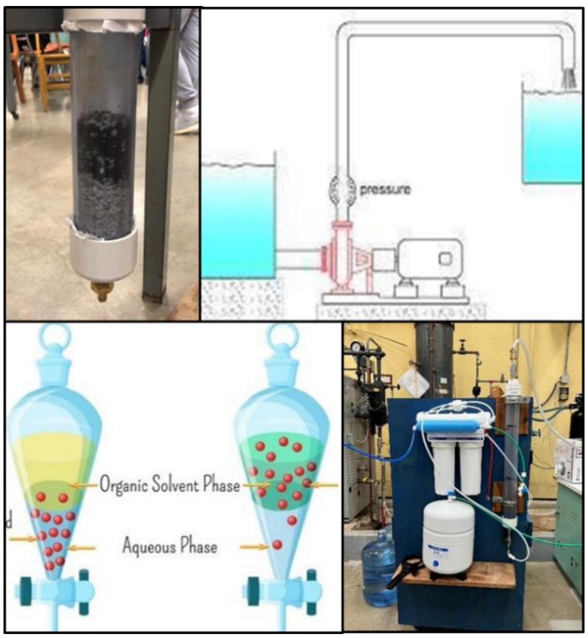


Figure 1. Typical devices developed by students in 2022 course offering.

Students reported that the team project was a highlight of this introductory engineering course, and that the instructor "provides assignments that get us (the students) thinking like engineers", as indicated in student end of course instructor evaluation. Additionally, the instructor observed reasonable teamwork activity on the part of students on this project. However, some groups ended up being nearly all a one-person show, which the instructor attributes to freshmen uncertainty and timidity in the university environment, and an indication that supplemental instruction in teamwork skills might be beneficial.

Electrical Engineering and Computer Science: Students in the Electrical Engineering and Computer Science section of the GEEN 1201 course were tasked with the design and development of a line following robot. The robot was required to be capable of following a path designated by a dark line on a light background. Student teams were provided with the parts necessary to construct a three-wheeled robot chassis along with motors capable of driving and steering the robot. Teams were also provided with a credit card sized computer board (Raspberry Pi), a motor controller, and infrared sensors. A 9-volt battery was supplied to power the robot drive wheels along with a power bank to provide power for the digital components.

Student teams were first instructed to assemble a chassis for their robot from the parts provided. The next step was designing the placement of the digital components, sensors, and power supplies needed for the robot. Care was required to ensure the placement of parts, especially the relatively heavy power bank, would not cause the robot to become top heavy and unstable. The teams were then supplied with jumper wires in order to make the necessary connections between the processor board, motor controller, sensors, and power supplies. A fully assembled line following robot is illustrated in Figure 2.

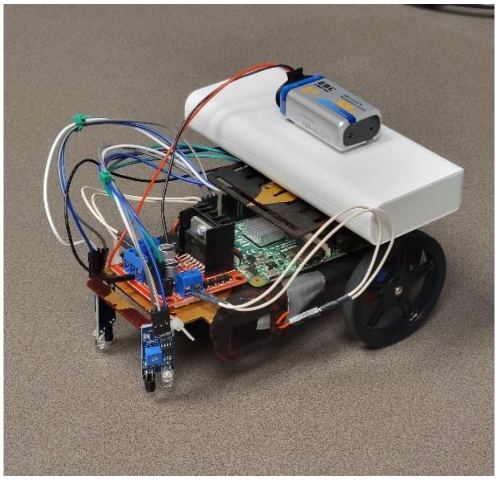


Figure 2. A fully assembled line-following robot.

The student teams were also required to code a guidance program for their robot that could run on the provided processor board. The program needed to be capable of reading and processing data from the infrared sensors of the robot and make steering adjustments as necessary to enable the robot to detect and follow a line. Steering was to be accomplished by making adjustments to the speed of the robot's two drive motors.

Student teams were given approximately five weeks to complete their design projects. At the conclusion of the project a competition was held to determine which team's robot could successfully navigate each of two different test tracks in the shortest amount of time.

Mechanical and Industrial Engineering: Students in the Mechanical and Industrial Engineering section of the GEEN 1201 course worked on building a 3D printed remote control (RC) car. Student teams were instructed to design parts for the RC car using the SolidWorks CAD software package to simulate the designs to check for potential improvements/errors. All the electronic components such as the control panel, receiving panel and motors were provided to the student teams. Students were also provided with all necessary instructions for the software and hardware used in the project.

The teams first started to work on the chassis design of the RC car. The main considerations for the chassis design focused on the placement of the electronic components and the steering assembly. Students were given four weeks to complete their chassis design with no design errors. The chassis designs were later 3D printed using two different technology 3D printers namely Stereolithography (SLA) and Fused Deposition Modeling (FDM) printers. The reason to print on two printers was to check which works best for the design considering the weight and accuracy of the printed parts.

After the chassis designs were 3D printed, all the electronic components were assembled to the chassis. While 3D printing it was discovered that the parts printed on the SLA printer were heavy and brittle, so the students printed all the parts using an FDM printer. The students initially had difficulties with the steering assembly, which was later fixed with some minor design changes. Figure 3 shows a 3D printed chassis design with the electronic components assembled.

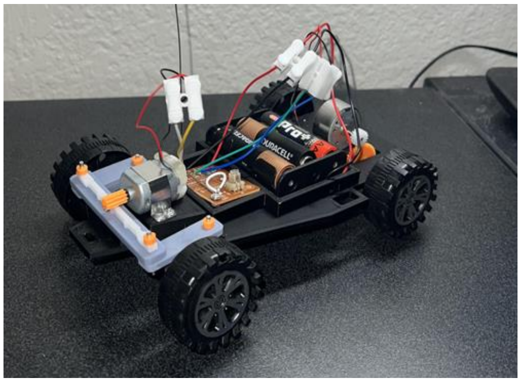


Figure 3. 3D printed RC Chassis with electronic components assembled.

Figure 4. Final 3D printed RC car.

Finally, the student teams worked on the body of the car, which were later printed on an FDM 3D printer. The student teams came up with some interesting body designs. Figure 4 shows a final completed 3D printed RC car. All the student teams were successful in completing the project. The project proved to be an effective introduction to design, manufacturing and robotics, which are considered major topics in mechanical engineering.

Civil and Architectural Engineering: The engineering design project utilized for the GEEN 1201 introductory course for the CAEN students was the design, construction, and evaluation of a trebuchet. Each student team was required to build and demonstrate the firing of a working trebuchet with a 12" arm. At the start of the project students were introduced to the concept of a trebuchet along with an overview of its history. Multiple videos were then viewed by the class on the construction of both miniature and full-scale models of a trebuchet.

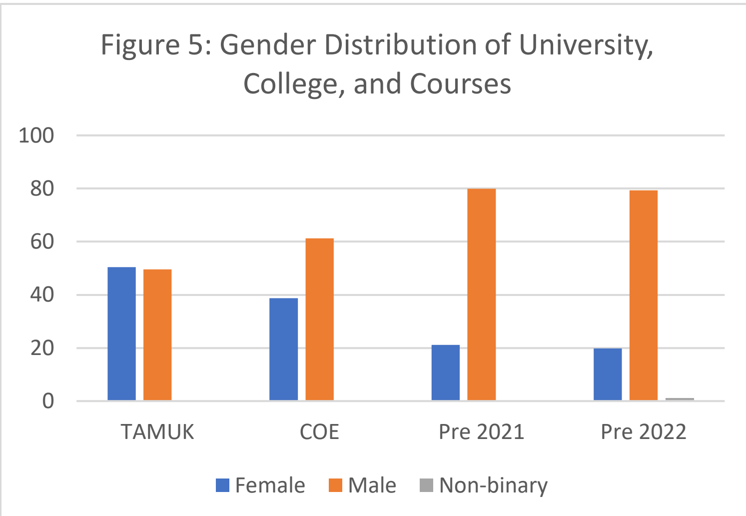
To facilitate the design and development process, student teams were next provided with the materials needed to build a trebuchet including a 12" bass wood arm, bass wood for framing, tongue depressors, glue, and a 0.75" ball for ammunition. Upper-level student mentors were available to assist teams with construction and troubleshooting. At the midpoint of the project, students met to fire their trebuchets. Success was measured in terms of both forward motion of the projectile and repeatability.

The student teams were next asked to evaluate the design and construction of their trebuchet. Two methods were utilized for evaluation. The first was a calculus based mathematical evaluation which was demonstrated to students by an instructional video viewed in class. The second was an automated evaluation process in which a software tool was used to analyze video recordings taken of the team's test firings of their trebuchet and the flight path of the projectile. Student mentors were again made available to assist in the evaluation process. Inclusion of the analysis process in the project in addition to the design and construction steps was intended to help students develop a practical connection between analysis and physical development, reinforce an understanding of experiment development, and develop self-reliance and self-confidence in engineering design.

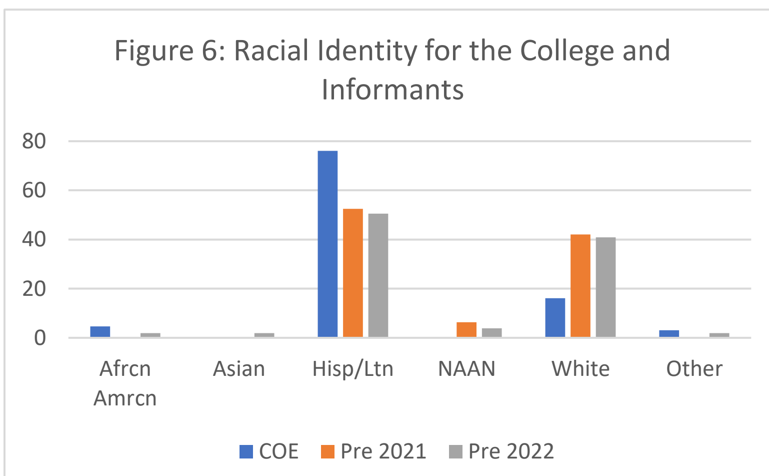
Results

Pre- and post-participation surveys regarding the hands-on projects were conducted in the three sections of GEEN 1201 in 2021 and all four sections in 2022 as were institutional end-of-course surveys. The post-participation survey did not request demographic information as that information was part of the pre-participation sample.

The College of Engineering (CoE) student population has a higher concentration of males than the university's total enrollment (Figure 5). But comparison of the pre-instruction data to the CoE enrollment indicates the sample skewed male. The gender shift was most pronounced in the EECS and MIEN sections with 96.8% and 82.7% of informants, respectively, identifying as male. The two remaining courses had gender distributions that included more females than the CoE enrollment, with the CAEN section at 47.1%, or slightly less and the CNEN section at 31.3%. The result was an overall gender ratio in the sample of approximately 2 females for every 8 males (there was one party in 2022 who identified as non-binary). Even though the percentage of females in the engineering courses appears low, the enrollment included sufficient numbers of students identifying as female for gender-based analysis of responses to be completed.



Racial identity among the informants also differed from the distribution for the College of Engineering (Figure 6). The apparently lower percentage of Hispanic/Latino individuals and higher percentage of parties who identify as White must, though, be viewed in light of ethnic identity for a clear understanding to be formed. Many of the parties who considered their racial identity to be White also classified themselves as Hispanic/ Latinx in respect to ethnicity (62.8%), which is not uncommon. This places the percentage of informants who identify as Hispanic/Latinx above the institutional and college average (85.7% in the sample, 76.1% for the CoE, 68.4% university). Thus, the sample could be considered as skewing slightly Hispanic/Latinx even though the disaggregation by race clouds that fact. As is the case for gender, there were sufficient counts of identifying as Hispanic/Latinx and non-Hispanic, for analysis by ethnicity to be completed.



The Mann Whitney U statistical test was used in the analyses as the samples were not normally distributed. Seven general engineering questions were asked of informants in each course. A ten-point scale was used in responses with students instructed to submit a rating of zero for "100% disagreement" and ten for "100% agreement." A summary of the results appears in Appendix 1 (Table 1). Since some of the post-participation samples for course sections were small and some students did not respond to all the questions, the informant groups were too small to uniformly meet the assumptions for meaningful statistical analysis if disaggregated by section (18, 10, nine, and six informants, respectively, for the MIEN, EECS, CNEN, and CAEN sections) especially if combined with demographic characteristic (groups as small as one informant). Thus, the analyses are reported for cumulative sets of responses in Table 1 which reflect data from two years for all but the CAEN section, Architectural and Civil Engineering, which was added to the course revision group in fall of 2022. Analyses reported are the product of unpaired *t* tests.

Informant responses included statistically significant differences pre- to post-instruction. These were for confidence in ability to work as a member of a team on an engineering project, knowing the basics of the engineering design process, knowing how to do engineering experimentation, familiarity with means of analyzing data, and knowing how engineers do problem solving. Overall, the students indicated learning in key areas of competence for engineers although the learning did not result in a statistically significant increase in interest in becoming an engineer or certainty that the field was "for" the informant. The latter two being non-significant may be a product of the high interest in and commitment to engineering present in the pre-participation responses.

The size of the combined sample facilitated consideration of responses to the seven general engineering questions, five about skills and one each about interest in and commitment to becoming an engineer, by gender and ethnicity (Appendix 1, Table 2). Two significant findings occurred for gender, with students identifying as female reporting greater familiarity with ways to analyze data and more knowledge of how engineers do problem solving than their male peers. This may be the result of a stronger background in mathematics or research or be a result of an intervening variable. Further investigation is required to identify defensible cause for the difference.

Analyses were also completed by ethnicity. There were as many as 91 Hispanic/Latinx and 19 non-Hispanic informants, counts varied by question as some students elected not to answer individual queries. None of the comparisons by ethnic identity for responses to the general engineering questions yielded a significant result (Appendix 1, Table 3).

Questions were also asked about discipline-specific understanding, skill, ability, and interest (Appendix 1, Table 4). The prompts were developed from the objectives for the hands-on design projects. The intention was to measure whether the intended goals were achieved. A ten-point scale was used in responses with students instructed to submit a rating of zero for "no understanding" and ten for "full understanding." Because these data are specific to the course sections, the samples were too small to support disaggregation. The pre- and post-instruction response count is noted in Table 4 for each prompt with many below 20 informants and some as low as five or six. Response counts at those levels result in a greater weight for each party's submission and decrease ability to rule out randomness. That potential is seen in the responses from the CAEN section. All the pre- to post-participation comparisons moved in the desired direction by one or more points with standard deviations decreasing but none of the changes were pronounced enough to produce a statistically significant result. Despite the small informant counts, there were statistically significant findings for three of the four courses due to large differences in the responses pre- to post-instruction,

In every course, student ratings of course-specific learning moved in the desired direction for many if not all topics (Table 4). The CNEN section, which was for Chemical and Natural Gas Engineering students, produced four strongly significant results. These were for increased understanding of use of various materials in water treatment, design of water treatment systems, collection of applicable data, and the need for prototyping. Notably, the only mean that did not move in the desired direction was for operation of a peristaltic pump. This was a technical process that could have been performed by a limited count of students in each group. Even with these caveats, there is a strong and consistent pattern of reported learning in the CNEN course. Four of five means went up substantially with students also reporting that they found the hands-on project interesting and that they could recognize real-world applications for the information they had learned about water treatment.

As has already been noted, all the means shifted in the desired direction, pre- to post-instruction for the CAEN section, which was for Architectural and Civil Engineering majors. The very small response counts and less pronounced changes in the ratings did not result in significant differences although increased understanding was reported for all prompts and the students indicated they saw real-world applications for the information they had learned.

Ratings for all five of the learning-objective based statements for the EECS section, Electrical Engineering and Computer Science, resulted in significant changes. These were for robot chassis construction and wiring, experience using a computer board, ability to write Python programs, and being motivated by competing with classmates. Like for the other sections, students reported being interested in the hands-on lab activity and that they saw applications for their learning in real-world settings.

The MIEN section for Mechanical Engineering majors also produced five significant findings. These were for understanding of reverse engineering, using 3D software to do motion study, completing a design project including interference detection, and experience with product design. The Mechanical Engineering students also reported seeing real-world application for what they learned about reverse engineering and 3D modeling.

Table 5 in Appendix 1 presents detailed information from queries about learning, interest, and confidence that were deployed only on the post-instruction instrument. A ten-point scale was used for responses with students instructed to submit a rating of zero for “100% disagreement” and ten for “100% agreement.” As noted above, the informant groups were small and could not support meaningful disaggregation by course section or most other characteristics.

The post-instruction responses to the learning, interest, and confidence questions show a strong positive trend (Appendix 1, Table 3). All but one of the means, when ratings for negatively phrased queries are inverted, were near or above 8.0 on a scale with ten as the maximum rating of “100% agreement.” The standard deviations for the ratings were moderate. A simple summary is that informants reported substantial learning in all areas queried except writing skills, a strong increase in interest in engineering based on the hands-on projects, and increased confidence in personal ability to become an engineer resulting from the hands-on experiences.

Interest in the topics chosen for the hands-on learning projects and effective process facilitation may have contributed to the positive outcomes. Post-instruction questions regarding interest in the project topic were worded in the negative for each section but student ratings placed interest near or above the upper quartile in each course section. A set of responses to queries about the learning environment and process facilitation, such as were instructions comprehensive and easy to follow, was the grading pattern clear, was the instructor available to provide guidance, were necessary supplies and space readily available, resulted in uniform agreement at the upper fifth of the scale. This speaks well of the planning and execution of the hands-on design projects, a characteristic that would likely have contributed to the learning achieved, increased interest in engineering, and increases in personal confidence.

Completing analysis of the material in Table 5 in Appendix 1 by ethnicity and gender would allow comparison of the post-instruction data set with the pre-instruction set in a number of meaningful ways. This was, however, not possible as the post-participation informants, while a subset of the students enrolled in the courses, included parties who did not respond to the pre-participation survey (over 40% of the female post-participation respondents).

Conclusions and Future Directions

The hands-on projects implemented proved to be of interest to the students and effective. Students saw them as a highlight of the course and reported significant advancement resulting from them. This occurred as increases in confidence in ability to work as a member of a team on an engineering project, knowing the basics of the engineering design process, knowing how to do engineering experimentation, familiarity with means of analyzing data, and knowing how engineers do problem solving. There were also discipline-specific learning goals fulfilled at significant levels in three of four sections of the course with the ability to perceive "real-world application for the things learned" from the hands-on activity reported by all groups asked. Female students reported greater familiarity with ways to analyze data and more knowledge of how engineers do problem solving than their male peers at statistically significant levels on the pre-participation survey. The reason for this is unknown. These outcomes suggest substantial efficacy in and potential for student benefit from continued implementation of practical, experiential learning in the GEEN 1201 courses for all students. That they persisted across two years of programming and existed with two different sets of students suggests they may be generalizable to similar settings. Verification of these findings will be necessary through continued use of the hands-on projects. This will be completed in coming semesters.

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Appendix 1. Results Tables

Table 1

Cohort Level Responses to General Engineering Questions

Prompt	Period	*n*	Mean	Mode	SD
I am confident in my ability to work as a team member on an engineering project.	Pre	110	7.45	10	2.34
	Post	43	8.74***	10	1.43
I know the basics of the engineering design process.	Pre	106	5.32	5	2.47
	Post	43	8.44***	10	1.65
I know how to do engineering experimentation.	Pre	107	4.36	5	2.58
	Post	43	8.18***	10	1.67
I am NOT familiar with ways to analyze engineering data.	Pre	108	4.55	3	2.70
	Post	38	3.16**	0	3.12
I do NOT know how engineers do problem solving.	Pre	103	3.57	4	2.44
	Post	36	2.47*	0	2.77
I am very interested in becoming an engineer.	Pre	110	9.16	10	1.33
	Post	43	8.77	10	2.02
I am NOT certain that engineering is for me.	Pre	89	1.65	0	2.21
	Post	37	2.05	0	2.90

Note: * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 2

Pre-Participation Cohort Level Responses to General Engineering Questions Sorted by Gender

Prompt	Gender	*n*	Mean	Mode	SD
I am confident in my ability to work as a team member on an engineering project.	Female	23	7.57	10	2.75
	Male	86	7.38	10	2.21
I know the basics of the engineering design process.	Female	23	5.26	5	2.61
	Male	82	6.23	5	2.43
I know how to do engineering experimentation.	Female	23	4.35	5	3.04
	Male	83	5.31	5	2.45
I am NOT familiar with ways to analyze engineering data.	Female	22	3.59	3	2.89
	Male	85	5.72***	5	2.60
I do NOT know how engineers do problem solving.	Female	20	3.05	1	2.65
	Male	82	4.64*	5	2.38
I am very interested in becoming an engineer.	Female	23	9.39	10	1.09
	Male	86	9.98	10	1.39
I am NOT certain that engineering is for me.	Female	15	2.47	0	2.96
	Male	74	2.45	0	1.99

Note: * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 3

Pre-Participation Cohort Level Responses to General Engineering Questions Sorted by Ethnicity

Prompt	Ethnc	*N*	Mean	Mode	SD
I am confident in my ability to work as a team member on an engineering project.	Hspnc	91	7.41	10	2.36
	Not	19	7.63	10	2.23
I know the basics of the engineering design process.	Hspnc	88	5.26	5	2.42
	Not	18	5.61	5	2.69
I know how to do engineering experimentation.	Hspnc	89	4.47	5	2.58
	Not	18	3.83	5	2.54
I am NOT familiar with ways to analyze engineering data.	Hspnc	89	4.39	3	2.65
	Not	19	5.26	5	2.79
I do NOT know how engineers do problem solving.	Hspnc	84	3.52	5	2.37
	Not	19	3.79	5	2.69
I am very interested in becoming an engineer.	Hspnc	91	9.22	10	1.34
	Not	19	8.89	10	1.25
I am NOT certain that engineering is for me.	Hspnc	73	1.68	0	2.29
	Not	16	1.50	0	1.80

Note: * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 4

Prompts and Responses to Discipline-Specific Questions

Prompt	Period	*n*	Mean	Median	SD
CNEN Section					
I understand how different materials can be used to remove offensive chemicals in water treatment systems.	Pre	15	3.73	5	2.11
	Post	9	8.44***	9	1.57
I can design a basic water treatment system.	Pre	14	2.21	3	1.93
	Post	9	7.78***	7	1.69
I DO NOT know how to use a peristaltic pump.	Pre	15	7.6	10	3.70
	Post	7	5.42	5	2.87
I know how to complete refractive index readings with water samples.	Pre	12	0.67	0	0.94
	Post	8	8.13***	10	2.03
I can explain the need for a prototype-test-repeat approach in engineering design.	Pre	16	5.75	5	2.79
	Post	9	9.11**	10	1.10
I was NOT interested in the water treatment project.					
	Post	6	2.0	0	2.45
I see real-world applications for things I learned in the water treatment project.					
	Post	8	9.0	10	1.80
CAEN Section					
I can explain the way the positioning of a fulcrum impacts the effectiveness of a lever.	Pre	15	4.80	5	2.48
	Post	5	6.20	Mult.	2.56
I can explain stressors placed on the support structure of a trebuchet when it is operated.	Pre	14	5.50	8	2.77
	Post	5	6.60	7	2.24
I can list two or more things that effect the throwing distance of a trebuchet.	Pre	15	7.0	8	2.97
	Post	5	8.0	10	1.90

I can explain how kinetic energy is transferred to the projectile of a trebuchet.	Pre	15	5.80	8	2.95
	Post	5	8.20	10	1.60
I can list two or more forces that act on the arm of a trebuchet.	Pre	15	5.93	7	2.67
	Post	5	7.80	6	1.83
I can explain the significance of the relationship between the weight of the projectile and counterweight of a trebuchet.	Pre	15	6.53	10	3.03
	Post	5	7.60	10	2.06
I can document the distance traveled by a projectile thrown by a trebuchet through experimentation and calculate the expected average.	Pre	15	6.47	10	3.48
	Post	5	7.40	10	2.33
I see real-world applications for things I learned about forces, levers, and projectiles.	Post	5	8.20	10	2.23
EECS Section					
I can build a simple chassis for a mobile robot.	Pre	26	1.96	0	2.32
	Post	9	8.78***	10	1.81
I can mount electric motors and associated wiring to a robot chassis.	Pre	24	2.13	0	2.47
	Post	9	8.56***	10	2.31
I have worked with a computer board for a small robot.	Pre	21	1.14	0	1.93
	Post	9	8.78***	10	2.39
I can write a program in Python to process data for guiding a robot.	Pre	20	1.75	0	1.86
	Post	9	8.0***	10	3.30
I find it motivating to compete with classmates to see whose design project works best.	Pre	30	5.83	10	3.12
	Post	9	8.67**	10	1.76
I was NOT interested in the robot building project.	Post	4	0.75	0	1.30
I see real-world applications for things I learned in the robot building project.	Post	9	9.33	10	1.05
MIEN Section					
I understand the reverse engineering process.	Pre	44	4.98	10	3.25
	Post	18	8.33***	10	1.91
I CANNOT use 3D modeling software to design a mechanism.	Pre	40	3.53	5	2.66
	Post	14	2.79	1	3.80
I know how to use 3D modeling software to do motion study analysis.	Pre	42	2.36	0	2.51
	Post	18	8.05***	10	2.27
I have designed a product that fit a predefined set of specifications.	Pre	39	3.31	0	3.41
	Post	17	7.88***	10	2.19
I have used 3D modeling software to complete a design project.	Pre	38	2.97	0	3.50
	Post	18	9.17***	10	1.17
I have used 3D modeling software to complete assembly interference detection.	Pre	35	1.77	0	2.03
	Post	18	8.11***	10	2.42
I do NOT find design of mechanisms interesting.	Pre	34	1.24	0	2.22
	Post	13	2.46	0	2.95
I see real-world applications for things I learned about reverse engineering.	Post	18	8.72	10	1.28
I do NOT see real world applications for things I learned about 3D modeling.	Post	15	1.79	0	2.91

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; $^{+}$ = possible confusion regarding the rating scale for one student which significantly increased the standard deviation.

Table 5

Responses to Learning, Interest, and Confidence Queries

Prompt	*n*	Mean	Mode	SD
I learned about designing a system, component, or process to fill a recognized need.	41	8.32	10	2.10
I learned how to conduct experimentation in engineering.	43	8.53	10	1.80
I learned NOTHING about analyzing data and interpreting the results.	32	1.25	0	2.28
I learned an engineering design process.	43	8.30	10	2.52
I learned problem solving patterns applicable to engineering.	42	8.47	10	2.00
I learned NOTHING about writing for engineering during the process of creating the project report.	31	2.97	0	3.54
I learned what is relevant for an engineering presentation while preparing my team's project presentation.	42	7.95	10	2.51
The hands-on project increased my interest in engineering.	43	8.70	10	2.09
The hands-on project increased my confidence that I can be an engineer.	42	8.52	10	2.10