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# Exploring Engineering Technology: A Multi-Disciplinary, Project-Based Introduction to Engineering Technology

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# Exploring Engineering Technology: A Multi-Disciplinary, Project-Based Introduction to Engineering Technology

**Abstract**

This Complete Evidence-Based Practice paper presents 'Exploring Engineering Technology,' a multi-disciplinary, project-based course designed to introduce new and prospective engineering students to the field. Choosing engineering as a major could be influenced by many factors, such as demographics, achievement scores, social contacts, mentors and role models, and the learning experiences from pre-high school to the first year in college. However, many students beginning their engineering studies often lack a clear understanding of the details of an engineering curriculum and the profession. A significant number of first-year students, and occasionally second-year students, lack a comprehensive understanding of the engineering field, including its diverse roles and specialties across various disciplines. As a result, dissatisfaction, misinformation, and high dropout rates continue to be significant challenges in engineering programs.

Focused on Mechanical, Electrical, and Computer Engineering Technologies, this course addresses the challenges students face in understanding the engineering curriculum and profession. It aims to guide students to make informed decisions when selecting their academic major. The course, developed collaboratively by faculty across three engineering technology departments and the First-Year Programs, centers on a hands-on project involving an automated robotic system for testing and sorting light bulbs, simulating real-world engineering applications.

This paper discusses the course's design, objectives, and pedagogical strategies. It includes a literature review on factors influencing engineering major choices and highlights the importance of addressing students' misconceptions and lack of understanding about engineering. The curriculum's multidisciplinary nature and project-based learning (PBL) approach emphasize hands-on experience and real-world applications. The core project involves developing a robotic system, illustrating the integration of mechanical design, electronics, and programming, and fostering a comprehensive educational experience. The learning outcomes focus on fostering understanding across the three engineering disciplines, enhancing teamwork, problem-solving, and multi-disciplinary collaboration, and exploring college success practices. Assessment results from a pilot implementation show positive trends in students' comprehension of engineering disciplines, academic readiness, and confidence.

## 1. Introduction

Choosing a major is a pivotal decision in a student's academic journey, setting the course for their future career and professional development [1], [2], [3], [4]. Engineering is a cornerstone of modern society, driving innovation, solving complex problems, and improving the quality of life for people around the globe. As a field of study covering a broad range of disciplines, including mechanical, electrical, civil, and computer engineering, engineering offers diverse career paths and opportunities. However, the decision to pursue a major in engineering is not one to be taken lightly, given its rigorous curriculum and the demands of the profession. As a result, understanding engineering as a major is paramount, not only for individual students but also for the broader context of engineering education and the engineering profession as a whole [5], [6], [7].

Students entering engineering programs face a variety of challenges that can impact their academic and personal lives [5], [8], [9], [10]. For starters, engineering programs are known for their rigorous curriculum, which includes advanced mathematics, science, and engineering principles. The high academic standards and workload can overwhelm students, especially in their first-year [8], [11], [12]. Moreover, for many students, entering an engineering program coincides with their transition to college life. This adjustment period can be challenging as students learn to balance academic responsibilities with personal and social activities. Another challenge regarding curriculum is the fact that early engineering coursework often focuses on theoretical knowledge without showing students the connection between their studies and real-world engineering challenges and their future careers [13], [14]. This can affect motivation and engagement [15]. Additionally, engineering courses' projects often require teamwork, yet new students may still need to develop the necessary communication and collaboration skills [16], [17], [18]. Learning to work effectively in diverse teams can be a significant challenge. Also, engineering fields have historically been male-dominated, which can create an unwelcoming environment for women and underrepresented minorities. This lack of diversity and inclusion can lead to feelings of isolation and discouragement [19], [20], [21]. Furthermore, the demanding nature of engineering programs requires excellent time management skills. Students must learn to effectively prioritize tasks and manage their time to meet deadlines and maintain a healthy work-life balance. Addressing these challenges requires a supportive educational environment that offers resources for academic support, personal development, and professional growth. Institutions can help students overcome these hurdles by providing mentoring programs, academic advising, mental health services, and opportunities for hands-on learning and real-world problem-solving [16], [22], [23], [24], [25], [26].

This paper introduces the design and implementation of City Tech's 'Exploring Engineering Technology' course, which aims to address some of the challenges mentioned above. The core of the course centers on developing an automated robotic system designed for sorting light bulbs—a task that emulates real-world multi-disciplinary applications. The main objective of this course is to help incoming engineering students, especially those interested in Mechanical, Electrical, and Computer Engineering Technologies, understand the details of different majors. This project-based course exposes students to the typical tasks engineers and technologists undertake in each major and demonstrates real-world applications. The course can empower students to make educated decisions regarding their major and future careers.

The rest of the paper is organized as follows. The second section presents a literature review discussing the factors influencing students' choice of engineering majors and highlighting the issues related to students' lack of understanding of engineering. Section three describes the course design and objectives. Section four presents the details of the core project, discussing the project's hands-on and multi-disciplinary nature, as well as its connection to academic expectations in the engineering disciplines encompassed within the curriculum. Section five presents the key learning outcomes integrated into the development of the robotic system and discusses how the project empowers students to analyze it from different engineering disciplines. Section six describes the course assessment methods, including the post-course survey and an analysis of students' responses from a pilot implementation, focusing on their comprehension of engineering disciplines, readiness for academic challenges, and confidence. Section seven discusses how students' feedback has been used to enhance the course and the next implementation. Finally, the last section concludes by reflecting on the effectiveness of the course, arguing the potential impact of this course on students' academic and career decisions.

## 2. Literature Review

A student choosing an engineering major is influenced by factors ranging from personal interests and abilities to external influences like family, educators, and societal perceptions [3]. ***Personal interest and abilities*** in science, technology, engineering, and mathematics (STEM) subjects are foundational factors influencing students' choice of engineering as a major [4], [5]. ***Self-efficacy*** related to mathematics and science abilities is a predictor of students' decision to pursue engineering majors [2]. This interest often stems from positive ***experiences in high school*** science and mathematics courses, which can spark curiosity and a desire to solve practical problems using these skills [9], [27], [28]. The presence of ***role models and mentors*** in the engineering field can inspire students to pursue engineering majors. This influence can come from family members, teachers, or professionals who provide insight into the engineering profession, offering guidance and encouragement [3], [19], [29]. Another influencing factor is **the perception of the engineering profession**. The perception of engineering as a field with high earning potential and job security is a significant motivator for students [2]. The demand for engineers in the job market and the prestige associated with engineering professions contribute to students' attraction to these majors. Students with a clear understanding of what engineers do and the societal impact of their work are more inclined to choose engineering [2], [14], [30].

However, many students beginning their engineering studies often lack a clear understanding of the details of an engineering curriculum and the profession [10]. Petroski [6] highlights that many first-year students, and occasionally second-year students, lack a comprehensive understanding of the engineering field, including its diverse roles and specialties across various disciplines. The lack of understanding about engineering among students entering and considering this field presents several critical issues that impact both the individual's academic success and the broader engineering community.

Students often choose engineering majors based on ***superficial or inaccurate perceptions***, leading to misalignments between their expectations and the realities of the profession [7], [31]. Without a clear grasp of the engineering curriculum's demands, students may struggle with the rigorous coursework, especially in mathematics and science, undermining their confidence and persistence in the field [13]. This also contributes to higher dropout rates as students confront unexpected challenges and become disillusioned with their chosen major [32]. The lack of understanding and exposure disproportionately affects women and underrepresented minorities, perpetuating stereotypes and discouraging their participation in engineering [19], [20]. Moreover, a superficial understanding of the multidisciplinary nature of engineering can hinder students' ability to contribute to innovation and effectively address complex, real-world problems [26]. Students with a limited overview of the engineering landscape may need help selecting a discipline that aligns with their interests, which could lead to dissatisfaction and changes in major.

These issues underscore the need for comprehensive outreach and academic efforts to demystify engineering for prospective students and promote diversity and inclusivity within engineering programs. Enhancing K-12 STEM education, offering realistic previews of engineering curricula, and providing mentorship from diverse engineering role models are essential strategies for bridging the understanding gap. Additionally, universities' first-year experiences should accurately reflect the nature of engineering work, encouraging persistence by aligning student expectations with the realities of the profession. By clarifying the nature and opportunities of engineering majors, educators can better support students in making informed decisions about their academic and professional futures.

**3. Course Design and Objectives**

This course is a small component of a Title V project, the City Tech STEM Success Collaborative, funded by the US Department of Education, aimed at enhancing retention, graduation rates, and workforce readiness among Hispanic and low-income students interested in STEM fields. The project emphasizes the early academic support and integration of academic resources to foster career awareness, engagement, multidisciplinary collaboration, hands-on problem-solving, and alignment with current industry practices. This initiative aims to streamline the educational journey, minimizing time to degree completion and reducing the accrual of non-contributory credits.

*Course objectives*

The 'Exploring Engineering Technology' course provides a multidisciplinary, project-based introduction to engineering technology. It is designed to equip new engineering students with the knowledge and practical experience necessary to make informed decisions about their major and future careers. The course has five primary objectives:

1. Introduce Mechanical, Electrical, and Computer Engineering Technology through a hands-on, project-based approach.
2. Highlight career paths, pay scales, job expectations, and the skills required in these fields and engineering at large.
3. Offer practical experience with a robotic system that simulates a real-world automated production line.
4. Guide students in making educated decisions when selecting their major.
5. Introduce common college success practices, resources, and services available at the college.

*Curriculum development*

Developed collaboratively by faculty across Mechanical, Electrical, and Computer Engineering Technology departments, with cooperation with the First Year Programs, the curriculum adopts a multidisciplinary approach, as shown in Figure 1. The curriculum is tailored for new students undecided on their major, those interested in engineering, and individuals seeking to explore engineering before fully committing. It is structured around project-based learning (PBL), centering on a project that mirrors industrial scenarios—a robotic system designed for picking up, testing, and sorting light bulbs. This project requires students to engage in various engineering tasks, such as designing the light bulb holder, creating circuits for sensor integration, programming the robot’s microcontroller, and system testing.

Project-based learning (PBL) is a dynamic classroom approach in which students actively explore real-world problems and gain knowledge and skills through developing real products [25], [26], [33]. PBL fosters an active learning environment where students tackle real-world problems, enhancing their knowledge and skills by producing tangible outcomes. This method not only deepens understanding of engineering principles through practical application but also boosts motivation and interest in the field [33]. The cross-disciplinary nature of PBL prepares students for the collaborative, interconnected world of engineering, promoting essential professional skills like teamwork, communication, and time management, which are highly prized in the industry [16], [17], [18].

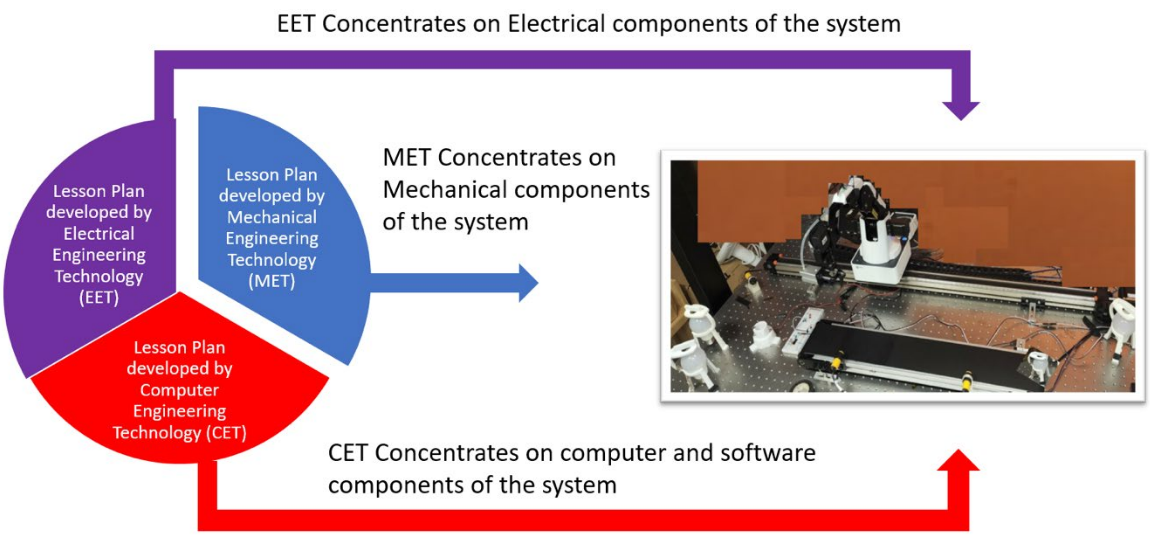



**Figure 1 Framework for developing the curriculum of "Exploring Engineering Technology."**

*Addressing the knowledge gap*

The similarities and nuances among different engineering and technology disciplines can be subtle, often making it challenging for newcomers to grasp. Many students enter engineering technology programs with limited understanding of their chosen fields, a gap stemming from the inherent complexity of engineering disciplines and insufficient pre-college exposure to these fields. This lack of clarity contributes to high attrition and transfer rates among students in their second or third year of study [6], [10], [12]. The course specifically aims to bridge this knowledge gap by not only providing insights into the practical aspects and real-world applications of mechanical, electrical, and computer engineering technologies but also discussing the job options in each discipline, the job expectations, and the skills required, and the corresponding jobs' salaries. Through direct exposure to the tasks and challenges engineers and technologists face, the course empowers students to make informed decisions regarding their major and career trajectory.

The curriculum includes some First-Year Program activities aimed at supporting new students' transition to college. Students explore college success practices, learn instructional technologies, access resources and services available at the college, utilize special college vocabulary, and work with professors and peer mentors.

*Course structure*
Designed for incoming high school recent graduates with no background in engineering or robotics, this course is structured into four focused sections. The initial three sections study distinct engineering disciplines—each combining lectures and labs to equip students with the necessary knowledge to start hands-on the project involving the robotic system. This setup not only facilitates immediate application of theoretical concepts but also introduces students to the professional landscape of each engineering field. Participants gain insights into potential careers, required technical and interpersonal skills, and salary expectations, emphasizing the importance of teamwork in the engineering profession. Each section of the course also includes activities related to college success practices.

## 4. Robotic System Development

To align with the course's objectives, the chosen project needed to incorporate elements from Mechanical, Electrical, and Computer Engineering disciplines, mirroring real-world robotic applications, and providing a foundation in electronics, mechanical design, and computer programming. Consequently, the project and robotic system depicted in Figure 2 was selected for its comprehensive educational value.

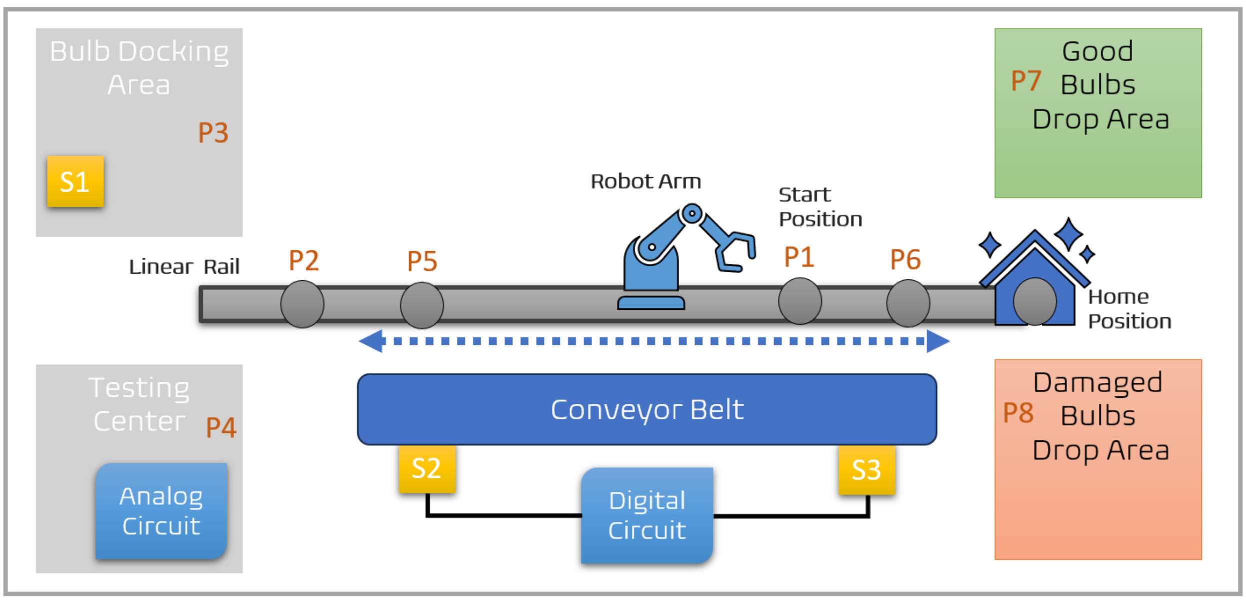
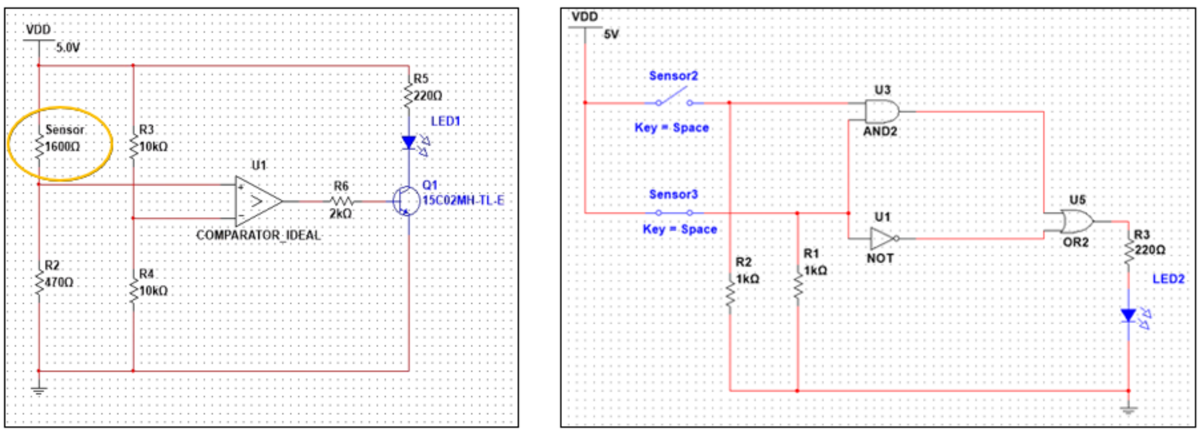



**Figure 2. Robot workcell. S1, S2, and S3 are sensors. P1 to P8 represent strategic positions the robot must move or reach to achieve its task.**

*Overview of the robotic system*
The project involves an automated production line designed to differentiate bad and good LED light bulbs and sort them accordingly. The system consists of the Dobot® Magician Robot, a desktop-grade 4-axis robotic arm, equipped with a Sliding Rail Kit and a Mini Conveyor Belt Kit from the same company, as shown in Figure 1. With the addition of sensors and some electronic circuits, as shown in Figure 2, the robotic system can execute a series of tasks, from picking up bulbs to testing and sorting them into designated areas based on their condition.

**Figure 3. 3D printed bulb holder and testing center.**




a) Analog circuit to detect good or bad LED bulbs.

b) Digital circuit for controlling the conveyor belt.

**Figure 4. Circuits used in the system. a) Analog circuit in the testing center. b) Digital circuit controlling the conveyor belt.**

The overall functionality process is depicted through a sequence of strategic positions and sensor interactions, as outlined below:

1. **Initiation**: The robot arm, mounted on a linear rail, moves to the Home Position for calibration. After the calibration is completed, the robot slides to the Start Position (P1).
2. **Picking a bulb up**: Bulbs are placed in a student-designed 3D-printed holder, shown in Figure 3When sensor S1 detects a light bulb in the Bulb Docking Area, the robot slides to the P2 position and moves the arm griper over to the Bulb Docking Area (P3) to pick up the bulb holder.
3. **Testing bulbs**: The robot transports the holder to the Testing Center (P4), where an analog circuit (described in Figure 4-a) determines the bulb's condition, indicated by the illumination of a green (good) or red (damaged) LED.
4. **Placing bulbs on the conveyor belt**: Upon testing, the robot slides to position P5 and places the holder on a conveyor belt. If S1 does not detect additional bulb holders, it waits; otherwise, it retrieves another bulb from P3.

5. **Conveyor activation**: The conveyor belt, activated by detecting the bulb holder at photosensor S2, transports the holder to the end, signaled by sensor S3. The sensors and the belt are controlled by a digital circuit described in Figure 4-b.
6. **Sorting process**: The robot then sorts the bulb into either the Good Bulbs Drop Area or the Damaged Bulbs Drop Area, depending on the test results.
7. **Reset**: The robot arm returns to its starting position (P1), ready to repeat the cycle.

The entire sequence is programmed by the students using Blockly, a graphical programming language [34]. The project emphasizes the multidisciplinary collaboration essential for the project's success. We envision working teams with students from the different engineering disciplines. This robotic system project not only showcases the integration of mechanical design, electronics, and automation but also emphasizes the real-world application of these engineering principles. Through hands-on experience, students gain a deeper understanding of each discipline's role within a larger engineering project, fostering a well-rounded educational experience.

## 5. Learning Outcomes and Pedagogical Approach

This course is structured to provide students with a clear understanding of Mechanical, Electrical, and Computer Engineering Technology. It is organized into dedicated sections for each discipline, culminating in a multidisciplinary group project. Additionally, adapted from the First Year Programs workshops, each section includes some outcomes aimed at helping new students transition to college life, specifically to City Tech. Below is a concise overview of the learning outcomes for each section, followed by the pedagogical approach employed to achieve these student learning outcomes.

*Section 1: Mechanical Engineering Technology*

- Recognize the fundamental aspects of the Mechanical Engineering field and its applications and understand the role of Mechanical Engineers in various industries.
- Understand the product development process, from design to manufacturing, with an emphasis on basic 3D modeling using CAD software.
- Follow the manufacturing processes, focusing on Additive Manufacturing (3D printing) and its implementation.
- Explore college success practices.

*Section 2: Electrical Engineering Technology*

- Recognize the essentials of Electrical Engineering and its applications and understand the role of Electric Engineers in various industries.
- Design basics Electrical Circuits (Analog and Digital), using breadboarding and circuit design theory.
- Recognize and utilize electronic components and equipment such as resistors, capacitors, semiconductors, sensors, and actuators.
- Develop basic computer programming skills for electronics.
- Identify campus resources and services to support a growth mindset, self-advocacy, and success.

*Section 3: Computer Engineering Technology*

- Recognize the fundamental aspects of Computer Engineering, its applications, and the role of Computer Engineers across industries.
- Describe how computers work: Hardware and software; the Input, Process, Output (IPO) model; storage, communications, and algorithms.
- Understand and use computational thinking as a problem-solving approach for designing systems and understanding human behavior logically and systematically.
- Design and develop programs to control physical components: Understand and combine simple control structures (conditionals, loops, functions) to create computer-controlled systems.
- Understand the importance of involvement in co- and extracurriculars and other college-affiliated activities.

*Section 4: Multidisciplinary Group Project: Robotic Light Bulb Testing System*

- Team Collaboration and Role Allocation. Students will form teams and assign roles to enhance collaboration and project management.
- Multidisciplinary Project Execution. Teams develop a robotic arm system, integrating mechanical, electrical, and computer engineering skills.
- System Testing and Problem-Solving: Students will conduct testing and troubleshooting, honing their analytical and problem-solving abilities.
- Presentation and Evaluation: The project culminates in a presentation in which teams showcase their systems, discuss the project's challenges and solutions, and receive feedback.
- Develop awareness of vocabulary unique to college life.

*Pedagogical approach*

**Multi-disciplinary Perspective**: This course encourages students to approach engineering problems from multiple disciplinary perspectives. By exploring each discipline separately before integrating them into a group project, students learn to appreciate the unique contribution of each field to solving complex engineering challenges.

**Integration of Theory and Practice**: The course blends theoretical knowledge with practical application. Students apply theoretical concepts to real-world scenarios through lectures, labs, and the final group project. This hands-on approach reinforces learning, enhances students' problem-solving skills, and prepares them for professional engineering tasks.

By adopting this comprehensive pedagogical approach, the course aims to equip students with a broad understanding of engineering technologies, making them understand the theory and use it in practical applications and multidisciplinary collaboration. The curriculum design aims to help new engineering students adapt to college, minimizing the time to degree completion and reducing the accrual of non-contributory credits by raising awareness about the curriculum requirements, job and career opportunities, and incorporating college success practices such as identifying campus resources and services to support a growth mindset, self-advocacy, and success.

**6. Assessment and Results**

We ran a pilot of the course during the summer of 2023. This course was piloted as a zero-credit pre-college course with 0 credits, 2 hours of lecture, and 2 hours of lab. The curriculum was covered over four weeks, with in-person meetings occurring Monday through Thursday. This pilot had ten students who were about to start their first year of college in the following Fall of 2023. The demographic information and the anticipated majors of these students are presented in Table 1.

**Table 1. Demographic information and anticipated academic majors of the students participating in the course pilot.**

<table>
<tr><th colspan="2">Gender</th><th colspan="4">Ethnicity</th><th colspan="3">Anticipated Academic Major</th></tr>
<tr><td rowspan="2">Males</td><td rowspan="2">Females</td><th colspan="2">Hispanic or Latino</th><th colspan="2">Not Hispanic or Latino</th><td rowspan="2">Electrical Engineering Technology (EET)</td><td rowspan="2">Mechanical Engineering Technology (MET)</td><td rowspan="2">Computer Engineering Technology (CET)</td></tr>
<tr><td>Black or African American</td><td>White</td><td>Black or African American</td><td>White</td></tr>
<tr><td>8</td><td>2</td><td>1</td><td>4</td><td>4</td><td>1</td><td>7</td><td>2</td><td>1</td></tr>
</table>

*Methodology*

To assess the effectiveness of the course, we developed a post-course survey. This survey also aims to help understand the course's impacts and improve its design. Ten students participated in this workshop, and eight responded to the survey. The survey evaluates two main aspects of the course: the students' understanding of the engineering discipline and their understanding of being prepared for college expectations. Our findings are listed below.

*About engineering*

As part of the survey, respondents were asked to rate their agreement to positively worded items on a scale of 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly agree. Initial items related to what they learned regarding engineering. As is shown in Table 2, average ratings ranged from 3.88 to 4.63. The items with the highest agreement ratings were:

- I learned about the role of electrical engineering while designing our project. (mean = 4.63)
- I learned about the role of computer engineering while designing our project. (mean = 4.50)
- I learned about engineering careers, including career options, job expectations, etc. (mean = 4.50)
- I learned what skills different engineering majors (mechanical, electrical, computer) need. (mean = 4.50)
- I would recommend this workshop to other students interested in understanding what majoring in engineering would be like at City Tech. (mean = 4.50)

The items with the least agreement were:

- This project helped me learn to work in a group. (mean = 3.88)
- I learned about the role of mechanical engineering while designing our project. (mean = 4.00)
- I learned how to create 3D models using CAD software. (mean = 4.00)

**Table 2 Complete list of survey questions and statistics related to the course and engineering concepts.**

| | n | Min. | Max. | Mean | SD |
|---|---|---|---|---|---|
| a. I found this workshop very engaging. | 8 | 3 | 5 | 4.25 | 0.71 |
| b. This workshop taught me what engineering entails. | 8 | 3 | 5 | 4.25 | 0.71 |
| c. I learned what engineers do by participating in this workshop. | 8 | 3 | 5 | 4.13 | 0.83 |
| d. I learned about the role of mechanical engineering while designing our project. | 8 | 3 | 5 | 4.00 | 0.93 |
| e. I learned about the role of electrical engineering while designing our project. | 8 | 3 | 5 | 4.63 | 0.74 |
| f. I learned about the role of computer engineering while designing our project. | 8 | 3 | 5 | 4.50 | 0.76 |
| g. I learned about engineering careers, including career options, job expectations, etc. | 8 | 4 | 5 | 4.50 | 0.53 |
| h. I learned what skills different engineering majors (mechanical, electrical, computer) need. | 8 | 4 | 5 | 4.50 | 0.53 |
| i. This project helped me learn to work in a group. | 8 | 3 | 5 | 3.88 | 0.83 |
| j. I had opportunities to practice communicating ideas as part of this project. | 8 | 4 | 5 | 4.38 | 0.52 |
| k. I learned to identify electronic components, parts, and signals. | 8 | 3 | 5 | 4.25 | 0.71 |
| l. I learned how to design electronic circuits. | 8 | 3 | 5 | 4.13 | 0.83 |
| m. I learned how to create 3D models using CAD software. | 8 | 2 | 5 | 4.00 | 1.07 |
| n. I learned how to design and develop a computer program to control physical components. | 8 | 3 | 5 | 4.13 | 0.83 |
| o. This workshop helped me understand what it would be like to major in engineering at City Tech. | 8 | 3 | 5 | 4.13 | 0.83 |
| p. I would recommend this workshop to other students interested in understanding what majoring in engineering would be like at City Tech. | 8 | 3 | 5 | 4.50 | 0.76 |

| | | | | | |
|---|---|---|---|---|---|
| q. I would recommend this workshop to other students interested in understanding what the different engineering majors are like at City Tech. | 8 | 3 | 5 | 4.25 | 0.89 |
| r. I am confident that I can identify the engineering major that best fits my desired career. | 8 | 3 | 5 | 4.25 | 0.71 |

*About City Tech*

A portion of this workshop was dedicated to helping students learn more about City Tech and ensure they are prepared for college expectations. Respondents were asked to rate their agreement to positively worded items about this aspect of the workshop on a scale of 1 = Strongly disagree, 2 = Disagree. 3 = Neutral, 4 = Agree, and 5 = Strongly agree. As shown in Table 3, average ratings ranged from 3.50 to 4.35. The items with the highest agreement ratings were:

- I feel more confident about my ability to be successful at City Tech from participating in this workshop. (mean = 4.25)
- I know where to go if I need academic help once I start City Tech. (mean = 4.00)
- I learned about expectations for college students (attending class, reaching out to professors, asking questions, etc.) (mean = 4.00)

The lowest-rated items were “I learned self-care strategies” and “I know where to go if I need counseling or other non-academic support once I start City Tech.” Both were rated 3.50.

**Table 3 Complete list of survey questions and statistics related to City Tech and college expectations.**

| | n | Min. | Max. | Mean | SD |
|---|---|---|---|---|---|
| a. I learned about expectations for college students (attending class, reaching out to professors, asking questions, etc.) | 8 | 3 | 5 | 4.00 | 0.53 |
| b. I learned about various resources available at City Tech such as the Student Success Center, Libraries, etc. | 8 | 2 | 5 | 3.63 | 0.92 |
| c. I learned about Growth vs. Fixed Mindset. | 8 | 3 | 5 | 3.75 | 0.71 |
| d. I learned about time management. | 8 | 2 | 5 | 3.63 | 0.92 |
| e. I learned self-care strategies | 8 | 2 | 5 | 3.50 | 0.93 |
| f. I feel more confident about my ability to be successful at City Tech from participating in this workshop. | 8 | 3 | 5 | 4.25 | 0.71 |
| g. This workshop taught me what skills I need to be successful at City Tech. | 8 | 3 | 5 | 3.88 | 0.64 |
| h. I know where to go if I need academic help once I start City Tech. | 8 | 3 | 5 | 4.00 | 0.53 |
| i. I know where to go if I need counseling or other non-academic support once I start City Tech. | 8 | 2 | 5 | 3.50 | 1.07 |

## 7. Constructive Feedback and Enhancement

*Student feedback*

Students were asked to indicate what they liked best about this course. Some stated that they liked what they learned (e.g., mechanical drawing, programming), whereas others liked learning about the different engineering paths and that much of the learning was hands-on. Specific comments were:

- *That it was 3 different types of engineering*
- *I learned how to develop a computer program.*
- *I liked all of the hands-on parts of the workshop.*
- *As a person who wants to be an electrical engineer, being able to learn more about the major as well as the specific kind of work they do and doing it has been an amazing experience during this workshop. Learning about other engineering paths also broadens my perspective on majors that could also do on the side.*
- *My favorite thing about the workshop was meeting some of the people in my major. I also was able to utilize some of the knowledge I gained from high school in this workshop.*
- *What I liked was the part of mechanical drawing which was 3D.*

*Areas for improvement*

Suggestions for improving this course were to make it longer, include as many hands-on activities as possible, and ensure that the mechanical portion is utilized in the final product. Comments are shown below.

- *I think this workshop could be longer and everything could be done from scratch as opposed to closely mimicking a previously designed project.*
- *You can increase the sections from 4 days.*
- *I think you guys are so focused on making sure we understand things that you over explain and end up complicating what you are trying to tell us.*
- *I think bringing different activities into the mix to better understand all 3 engineering paths would be a nice improvement for students to gain a better understanding.*

*Overall impacts*

Students were informed that one goal of the course was to help students understand mechanical, electronic, and computer engineering technology in detail. When asked how this workshop could better help students understand, some respondents expressed that it already did a good job of this. In contrast, others suggested that instructors share more about the different types of jobs associated with each and the differences in what these jobs entail. Specific comments included:

- *Do actual python. Learn how to design a different type of circuit.*
- *This workshop helped students understand the difference between the 3 types of engineering and how they work together to create a project like the one we built.*
- *To be able to understand more about the 3 electrical engineering pathways, learning more about each one as well as the different types of jobs they do. Showing examples of the kind of work they do could also help get a better sense of engineering.*
- *I would say continue to mention the differences between the various jobs in engineering to help make it clear to students what it is that they want to study.*
- *I would say the same way it taught me because I learned the difference in each major.*
- *Focus more on the hands-on portion of engineering.*

*Semester follow-up on pilot participants*
As mentioned above, ten students participated in the Summer 2023 pilot program and started their first year of college in Fall 2023. By the end of the Fall 2023 semester, eight of these students completed their coursework. Two students withdrew from all their classes during this period. However, one has since re-enrolled as a full-time student for the Spring 2024 semester, while the other has not returned.

The eight students who completed the Fall 2023 semester achieved an average GPA of 2.77, with individual GPAs ranging from a low of 1.315 to a high of 3.7. As of Spring 2024, all nine students currently enrolled have maintained their original major, indicating a strong alignment with their chosen field of study.

**8. Conclusions and Future Work**
The ‘Exploring Engineering Technology’ course was designed for new and prospective engineering students. It aims to provide a comprehensive introduction to three different engineering fields, emphasizing a project-based, hands-on approach. The course also highlights career pathways and expectations, offers practical experience with robotics akin to industrial applications, and aids students in making informed decisions when selecting their academic major.

Implemented in the summer of 2023 with an initial cohort of ten students, feedback indicated a positive reception to the hands-on learning approach and a desire for a more in-depth exploration of engineering careers and the practical work involved. Based on the students' responses to a survey, the course curriculum achieved its objectives.

However, only eight of the ten students completed their first semester with GPAs between 1.315 and 3.7 (average=2.77); two students withdrew. After one semester, nine of the students are still enrolled in their original major. One of the ten students did not return.

**9. Implications and Future Work**
Looking ahead, we aim to integrate this course into the standard first-semester curriculum across the involved engineering departments. This goal will require careful coordination and faculty support to ensure curriculum alignment among the three programs and foster a collaborative teaching environment. For summer 2024, plans are underway to host two course sessions, expand faculty participation in teaching the course, and recruit incoming sophomores. Based on initial feedback, we are refining some aspects of the curricular activities to enhance student engagement and learning outcomes.

Finally, we would like to offer a perspective grounded in our experiences and challenges encountered during the initial implementation at a large institution like ours. We have more than 2000 students enrolled in these three engineering programs and more than 650 First-time Freshman students every fall semester. Firstly, scalability is a significant hurdle even for a large college like ours. To accommodate a broader student body, substantial investments in equipment, around $4000 for each work cell for three to four students, and space are necessary. Secondly, integrating this multidisciplinary course into the packed curriculum of engineering programs presents another challenge. Most engineering programs, regardless of the institution's size, have densely packed schedules from the onset. Our experience highlighted the difficulty in carving out space for this additional course without displacing other crucial introductory courses.

Given the scalability and curriculum integration challenges faced at a large institution like ours, we anticipate that our course could be more feasibly implemented at small colleges or community colleges. Smaller class sizes at these institutions may alleviate the need for extensive resources and space, making the hands-on, project-based learning approach more manageable. Additionally, the flexible curriculum structures often found in smaller colleges could facilitate the integration of this multidisciplinary course without disrupting existing essential courses. Ultimately, the course's emphasis on practical, experiential learning aligns with the educational philosophies of smaller institutions, providing a unique opportunity for students to explore and understand the various engineering disciplines through collaborative projects, thereby enhancing their readiness for future academic and professional pursuits.

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