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Summer Engineering Program for Early High School Students

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Summer Engineering Program for Early High School Students

Abstract

Our university started a new pre-college program called Momentum for rising 9th and 10th-grade students in the summer of 2025. This one-week, commuter/day program was designed to give early high school students a chance to explore different disciplines in science, engineering, and design through a central academic course. Various courses were offered to expose students to different professional fields, including arts, science, architecture, and engineering. The academic portion for the selected field took place during the day, Tuesday through Friday, for 5 hours a day. All of the students in the Momentum program were introduced to a college environment and explored a field of study.

One of the courses was called Art and Science of Creating: “Engineering + Designing Tomorrow’s Products”. In this course, ten students enrolled. The main goal was to expose students to different majors through active learning. The course was developed by faculty from Computer, Electrical, and Mechanical Engineering, as well as Computer Science, Industrial Design, and Management.

Each faculty had a session with the students. Within the session, the faculty described their own experience in the field, and led a hands-on activity related to the program. This paper will describe and discuss the hands-on activities for Electrical Engineering.

The objective of our study was to describe and measure the impact of the Electrical Engineering activities within the Engineering + Designing Tomorrow’s Products course on the students’ affective and learning experience. After the course, the students expressed that they found the academic experience enjoyable and useful in helping them to identify their future college interests and majors.

Introduction

Pre-college summer programs can provide K-12 students with valuable experiences that reflect the rigorous environment of higher education and expose students to potential educational paths that they can pursue [1]. Summer programs allow students to engage with advanced coursework materials at the university level to obtain a better understanding of different fields through hands-on practical learning [1-3]. A pre-college program called Momentum has been developed as a one-week commuter summer program for rising 9th and 10th-grade high school students in our institution. This program lets students experience a college environment, while collaborating with new friends. This immersive learning program gave students a chance to explore science, engineering, design, or business. From the opportunity to get a sneak peek at college life to learning in the labs and studios, students were able to explore various engaging topics. Art and Science of Creating: “Engineering + Designing Tomorrow's Products” was one of the courses, and it included seven topics: Mechanical Engineering, Engineering Design, Computer Engineering, Electrical Engineering, Computer Science, Industrial Design, and Business/Entrepreneurship.

Momentum was open to rising freshmen and sophomores in high school. All interested students were required to submit the application form, a current high school transcript, and an essay detailing their interest in attending a pre-college program. 39 students attended the program and 10 of them joined the course Art and Science of Creating: Engineering + Designing Tomorrow's Products. Momentum is a tuition-based program and all students paid tuition to attend the program.

Program Implementation

The Momentum courses were developed and implemented for the first time in the Summer of 2025. The academic portion of the course "Art and Science of Creating: Engineering + Designing Tomorrow's Products" took place during the day, Tuesday through Friday, five hours a day. The main goal was to expose students to engineering and design through active learning activities. The one-week plan for the course is shown in Table 1.

Table 1 Plan for the Week

Art and Science of Creating: Engineering + Designing Tomorrow's Products				
	Tuesday	Wednesday	Thursday	Friday
9:00-11:30am	Mechanical Engineering (Material Science & Manufacturing	Industrial Design (Introduction to Design Principles & Product Development)	Engineering (Introduction to Engineering Design)	Electrical Engineering (Circuitry)
12:30-3:00pm	Mechanical Engineering (Material Science & Manufacturing)	Computer Science (Embedded Programming & Personalization)	Computer Engineering (Hardware-Software Integration)	Business/Entrepreneurship (Rapid Prototype, Marketing, Strategy)

The course was developed and conducted by four faculty from Electrical, Computer, and Mechanical Engineering programs in School of Engineering, one faculty from Computer Science in School of Computing and Data Science, one faculty from Industrial Design in School of Architecture & Design, and two faculty from Business Management in School of Management. Traditional summer programs focus on exposing students to solely undergraduate programs [1].

However, research has shown that introducing future career possibilities can motivate academic interest [1,4]. So we expanded our program's scope beyond academic exposure with professional development opportunities to provide students insight into practical aspects of engineering careers [1]. Each faculty shared with students their own experience in the field and potential job opportunities. Basic knowledge related to the major was introduced and followed by hands on activities.

This paper presents the learning activities that were developed for Electrical Engineering in the course. For this session, two activities were undertaken by the students: LEDs in Series and Basics of Signals. Two students were assigned to each group. The School of Engineering provided complete support in terms of equipment and software required for the program.

Electrical Engineering Activities

After the introduction of the field of Electrical Engineering and related career opportunities, basic concepts for electrical circuits and safety were discussed in class. The students were asked to measure their dry hand and wet hand resistance by a digital multimeter (DMM). The instructions were given below:

- Insert the red plug of the cable in the red socket and the black plug in the black socket of the DMM (yellow box in Figure 1)
- **Turn on** the DMM. Select the button Ω 2W to enable the DMM to measure resistance (red box in Figure 1).

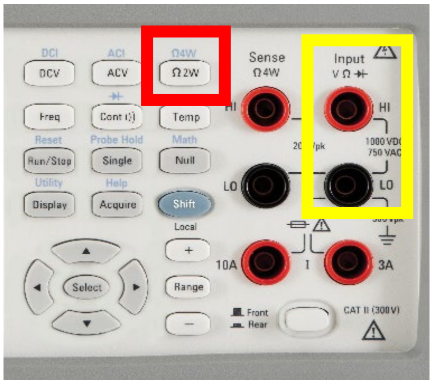

Figure 1 DMM to measure resistance

- With normal "dry" hands, use your fingers to pinch or hold the metal leads on the opposite ends of the cables plugged into the DMM. Each hand holds one cable, such as Left to Red, and Right to Black. Make sure to have the fingers touch the metal, not the plastic insulation. Record the Resistance displayed on the DMM in Table 2.

Afterwards, make your fingers wet with the provided solution. Then, using your wet fingers, repeat the measurements.

Table 2 Hand Resistance

Hand State	Resistance (from DMM)	Calculate Voltage Necessary to pass 20 mA V=(0.02A)(Hand Resistance)
"Dry" Hands		
"Wet" Hands		

If DMM reads Over-Load for resistance, use a value of R = 1 MΩ = 1,000,000 Ω

Then students followed the instructions given below to build their first circuit: LEDs in series.

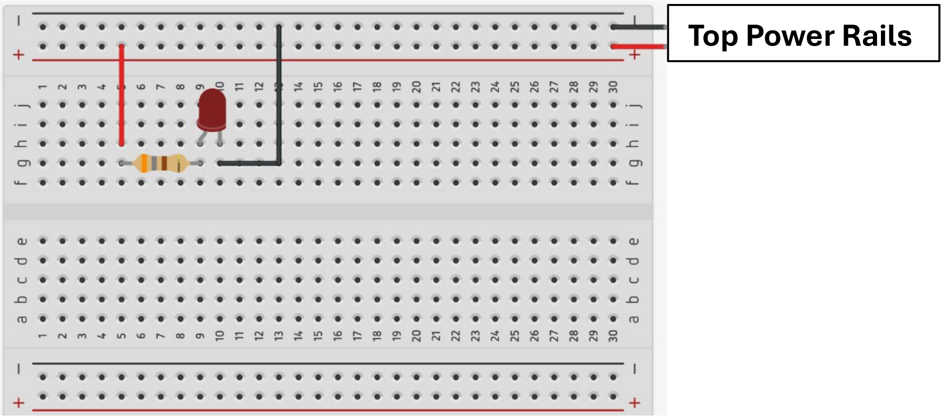

Figure 2: LED circuit

- Build the circuit on the breadboard as illustrated in Figure 2, using a resistor, LED and wires.
- Set the power supply to 9V and connect it to the breadboard at the marked Top Power Rails, with polarity as shown in the diagram.
- **Turn on** the power supply. Is the LED on?
- Turn on the DMM and select the DCV button to measure the voltage across the LED. Fill in Table 3.

- Select the light blue button shift and then the DCV button in the red box to enable the DMM to measure current through the LED (Figure 3). Fill in Table 3.

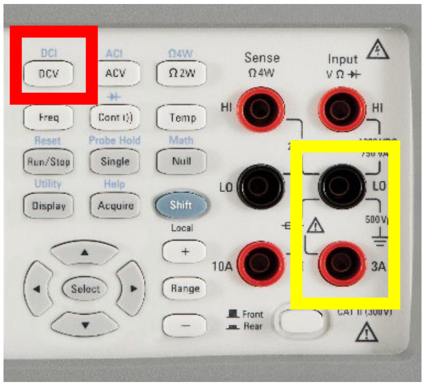

Figure 3 DMM to measure current

- Turn off the power supply output and add a second LED in series with the first LED. Fill in Table 3.
- Turn on the power supply and measure the voltage and the current. Continue adding one LED in series at a time and repeat the voltage and current measurement.
- Continue until something happens to the LED!
- Why do you think this is happening? Discuss with the instructor your ideas!

Table 3: LEDs in Series

Numbers of LEDs	**LEDs on?**	**Voltage [V]**	**Current [mA]**
1			
2			
3			
4			
5			
6			
7			
8			
9			

Then, the bench instruments of function generator and oscilloscope were introduced to students. Students worked on their second activity: Explore Signals.

In this activity, a function generator was used to drive an audio speaker.

- First, the function generator was set to produce a sinusoidal signal at a frequency of 600 Hz with a 0.1 V peak-to-peak amplitude (remember that the signal generator needs to be set for half that value at 0.05 V for amplitude). Observe the output waveform of the function generator on the oscilloscope by connecting them using a BNC cable.

- Use the BNC "T" to connect the function generator output signal to the oscilloscope and the speaker's input.

    - What happens to the sound when the amplitude of the signal coming from the signal generator is changed?
    - What happens to the sound when the frequency of the signal coming from the signal generator is changed?

- Determine the approximate upper and lower frequency limits of the speaker-to-human ear system. What is the highest frequency that you can hear? Do all members of your team have comparable low and high-frequency limits on what they can hear? Each person may be different. The commonly quoted limits of human hearing are 20 Hz to 20 kHz. Can you get close to those values? If not, consider reasons for why not? How does the apparent loudness of the sound change as you change frequencies? Which frequencies sound loudest? Why do you think this is? Are your results explained adequately by the sensitivity of the human ear, or does the speaker have something to do with it?

Discussions

The results show that overall the Electrical Engineering session was a success. All of the student teams were able to successfully complete the activities within the given time frame of the course. One group of students finished the activities earlier and worked on the extra activity: Tinkercad. AUTODESK Tinkercad is a free web app for 3D design, electronics, and coding. Without benchtop equipment and/or the electrical components, students can still build and test circuits at home. The students enjoyed the Electrical Engineering activities, and responded that the session had positively explored them to Electrical Engineering. Additionally, all students were interested in Tinkercard and downloaded the app before they left. Many of the students told the faculty that they would recommend the summer program to their friends and siblings, citing that it was a great program for students with little experience in engineering. And they had the opportunity to learn about the college and what a university-level engineering course is like. Most students also asked about another pre-college summer program offered by our institution: ImpactLab. ImpactLab is a two-week residential summer experience for rising juniors and seniors in high school. The students showed strong interest in this program and would like to come back next summer.

It's our first time to offer the pre-college program for rising 9th and 10th-grade students in summer 2025 and with low enrollment, so survey was not conducted. But surveys and more data will be collected in the summer 2026.

Conclusions

The pre-college summer course Art and Science of Creating: “Engineering + Designing Tomorrow’s Products” was motivated to expose students to engineering, design, and business fields, boost students' interests, and give them actual hands-on experience. This program could also, in the longer term, serve as a bridge to recruit new students into our university and train more students who are ready to fill the STEM-related job positions [5-8].

Two activities developed and conducted by Electrical Engineering faculty were presented in this paper. Positive feedback was received by the participants. Further directions include conducting a survey after each session to get students’ comments on our hands-on activities.

The experience gained from this program will help us to be more prepared and creative in organizing a similar program this year. We believe these experiences would also benefit other educators and researchers with the common goal of increasing the number of professionals in the STEM fields.

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