BYOE: A Multidisciplinary DIY Speaker Design Project

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Introduction

Project-Based Learning (PBL) is a key instructional method that engages students by having them tackle real-world problems through collaborative projects [1]. In engineering education, PBL not only integrates theoretical knowledge with practical application but also fosters critical skills such as collaboration, communication, and innovation. Research indicates that PBL is an effective pedagogical approach in engineering education [2] and is an ideal pedagogy to employ at the first-year, general engineering level, to develop these essential skills early on.

In the first year at the University of Melbourne (Australia), students interested in engineering take foundational science courses alongside the course titled *ENGR10006 Engineering Modelling & Design (EMD)*. This course employs PBL and is designed for all first-year students, aiming to develop essential engineering knowledge and skills while providing an authentic experience that encourages and prepares them to pursue an engineering major [3]. The course includes lectures on engineering problem solving, the engineering profession and project management, complemented by weekly, three-hour workshop classes, where students engage in a team-based project over a 12-week semester. Workshops combine interactive teaching of technical content and team-based project work. Students work in teams of three on one of several available projects over the full semester, selecting their project through the timetable system at the start of the semester. The different projects encapsulate a range of disciplines of engineering and are each multidisciplinary in nature. The focus of this "Bring Your Own Experiment" (BYOE) paper will be on one of these projects: the design of a speaker system.

The multidisciplinary DIY speaker design project helps develop first-year engineering students' understanding of the modelling, design, fabrication and experimental testing processes by taking them through the life cycle of a simple, engaging, low-cost physical engineering project. The project was developed to introduce first-year students, all of whom have not yet declared their major, to the interdisciplinary nature of engineering and expose them to aspects of both mechanical and electrical engineering, through exposure to the complex transformations of energy that occur in a speaker system [4].

From the mechanical engineering side, students learn computer-aided design (CAD) techniques to draw, fabricate and assemble a mid-range audio driver and speaker enclosure. From the electrical engineering side, students learn simple passive and active filters (at a functional depth) to implement and test such circuits on a prototype breadboard. Bridging the electrical and mechanical aspects of the project, students learn the importance of experimental measurements by testing their constructed speaker inside an acoustic test box, using a measurement microphone and free audio testing software. Students use frequency response test results as inputs to the design of their electrical circuits.

This paper serves as a guide to the finer details of the speaker project to help instructors integrate a DIY speaker design project into an existing or new multidisciplinary engineering project course for first or second-year students. It will begin with an overview of the project and intended learning outcomes, followed by a detailed week-by-week outline of the project work, necessary equipment, and student activities. Additionally, the paper will address the challenges faced during the project and the strategies employed to overcome them.

Project Overview and Timeline

An overview of the project's stages, its timeline and some of the relevant assessment components over the 12-week semester are given in Figure 1. Students work collaboratively in teams of three over the twelve-week semester in a weekly, three-hour 'workshop' class, which are a hybrid of instructor-driven and practical, project-focused activities. On average, we have had over 50 teams per semester.

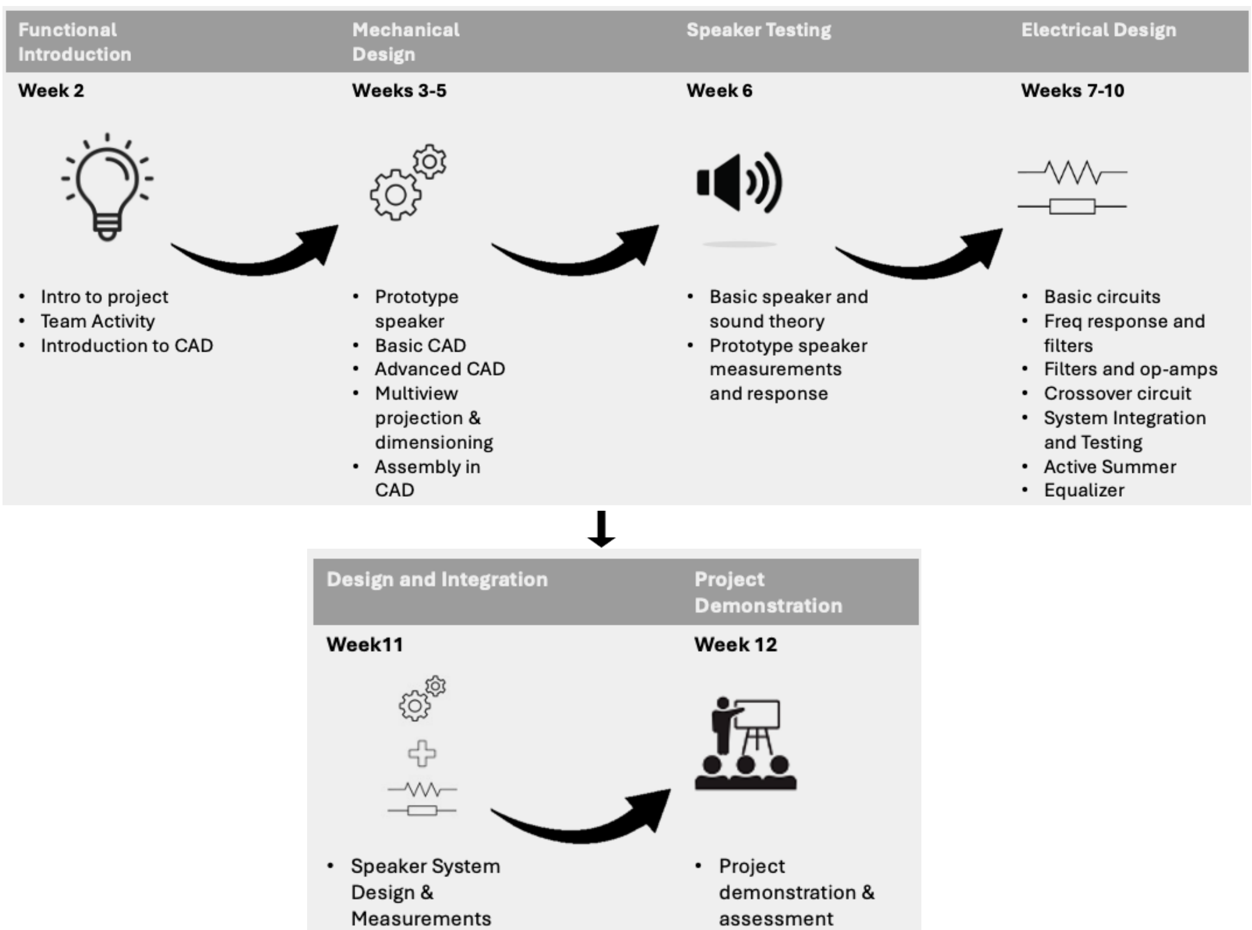

Figure 1: Project components, timeline and assessment.

The focus of this BYOE paper will be on the speaker system project setup and associated workshop activities; therefore, finer details of the assessment will not be covered.

Learning Outcomes

The intended learning outcomes (ILOs) for the first-year course are for students to able to:

1. Demonstrate a conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.
2. Develop and construct mathematical, physical and conceptual models of situations, systems and devices, and utilize such models for purposes of analysis and design.
3. Apply established engineering methods, techniques, tools and resources to complex engineering problem solving.
4. Apply systematic approaches to the conduct and management of engineering projects.
5. Demonstrate competency in current tools for analysis, simulation, visualization, synthesis and design, particularly computer-based tools and packages.

The speaker system design project aims to ensure that students achieve the course ILOs through a variety of teaching and learning activities, project work, and relevant assessments. A key factor in the project's success is its design, which promotes authentic, hands-on learning within a collaborative team environment.

How Speakers Work: Team Forming and Introductory Experiment (Week 2)

In the first workshop in Week 2, students explore how a speaker works by constructing a simple, functional speaker from the following provided parts:

- 1 vacuum-formed cone
- 2m of enameled copper wire (AWG 38)
- 1 neodymium disc magnet (15mm d x 7mm h, 4298 Gauss)
- Clear tape
- Sandpaper (small piece)

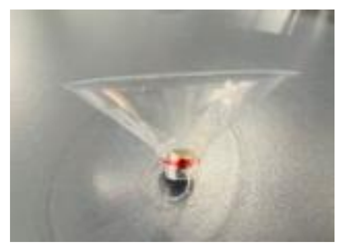

Figure 2: Simple speaker

Guided by step-by-step instructions, students construct the speaker shown in Figure 2. For illustrative purposes, the magnet is not shown in its final position, but instead where it is to be inserted at the bottom of the cone. Students then test this speaker by connecting it to a computer's headphone jack using a TRS 3.5mm cable and alligator clips as shown in Figure 3. The resulting sound is quite low, teaching students the need for audio amplification, which is accomplished using a provided Kemo M032S 12W mono amplifier module.

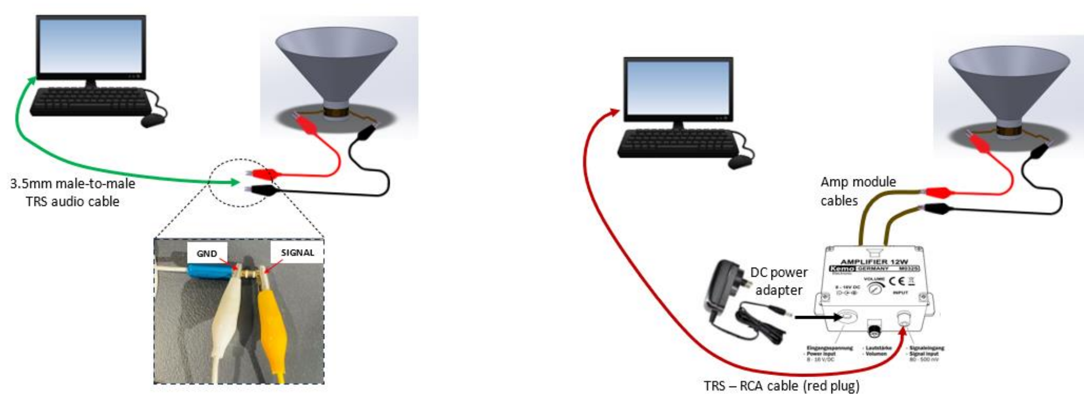

Figure 3: Speaker audio testing without (left) and with (right) an audio amplifier

Students grasp the core physical concept of a speaker and the complex transformation of electrical to mechanical energy by observing, and even feeling, the cone's movement, which is driven by the electromagnetic effect of the speaker coil (Ampere's Law). This movement results from the push and pull forces generated by the interaction of like and unlike magnetic field polarities with the magnet.

Mechanical Design & Implementation (Weeks 3 – 5)

With a basic understanding of how speakers work, students move onto the mechanical design part of the project which is completed over the next three weeks. No prior experience with SolidWorks or other CAD software is assumed with our first-year students, so students learn to draw, dimension and assemble parts during their weekly workshop sessions as well as through guided homework exercises they must complete before each workshop.

Students are given 2D technical drawings of the 7 unique parts making up the speaker driver chassis and the 4 unique parts forming the enclosure. An example of one of these drawings is shown in Figure 4.

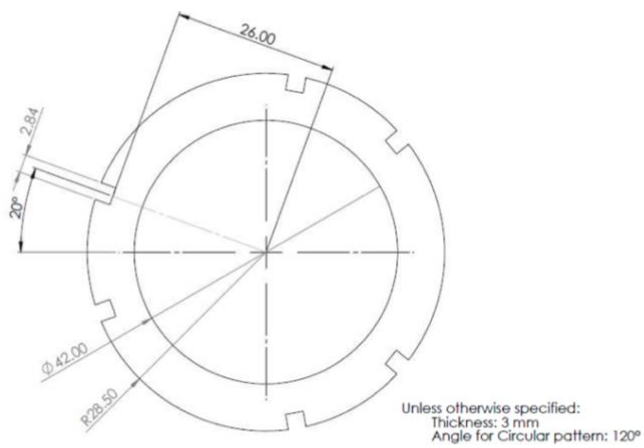

Figure 4: Example technical drawing showing the spider holder part of the speaker driver chassis

From these drawings and the SolidWorks skills they learn, each team must draw all parts to specification and laser cut them at our nearby maker space. Students also draw 3D models of the other provided speaker parts (cone, magnet, coil, and the spider and surround fabrics) and create a 3D CAD assembly of the prototype speaker.

The following materials are provided to students to make their prototype speaker:

- Medium-density fiberboard (MDF) (3mm thick)
- 1 x neodymium disc magnet 15mm x 7mm (4298 Gauss)
- 1 x neodymium disc magnet 12mm x 3mm (3306 Gauss)
- 1 x spider fabric (lycra)
- 1 x surround fabric (lycra)
- 3.5m of enameled 38 AWG copper wire for the speaker coil
- 1 x vacuum-formed speaker cone
- 2 x Molex ring terminals

- 3 x screws
- Glue and masking tape
- Solder

The total cost of the materials is low (less than $15 for each speaker and enclosure) with the most expensive parts being the two magnets and the MDF.

The following physical tools are available to students to help make their prototype speaker:

- Laser cutter
- Soldering iron
- Hammer (if necessary, to ease laser cut parts into slots)
- Sandpaper (for removing the insulation from ends of copper wire)
- File (if necessary, to help laser cut parts fit better)

Figure 5 shows the twelve laser cut parts that, when property connected, form the speaker chassis driver shown in Figure 6. An additional six laser cut parts form each side of the speaker enclosure shown in Figure 6. The provided cone and pre-cut lycra fabrics (spider and surround) are shown in Figure 7, and along with glue and the copper wire, form the cone assembly. Note that the cone needs to be rigid and light for better sound reproduction. We first attempted to use 3D-printed cones in keeping with a "from scratch" theme, but these did not perform well in tests during the course development stage. We settled on a vacuum-formed PETG[1] cone that can readily be reproduced in quantity each semester.

A: Top Plate
B: Insert (6mm x 8mm)
C: Disc
D: Base Plate
E: Support Panel
F: Spider Holder
G: Surround Holder

Figure 5: The twelve laser cut parts that form the speaker driver chassis

[1] PETG stands for polyethylene terephthalate glycol

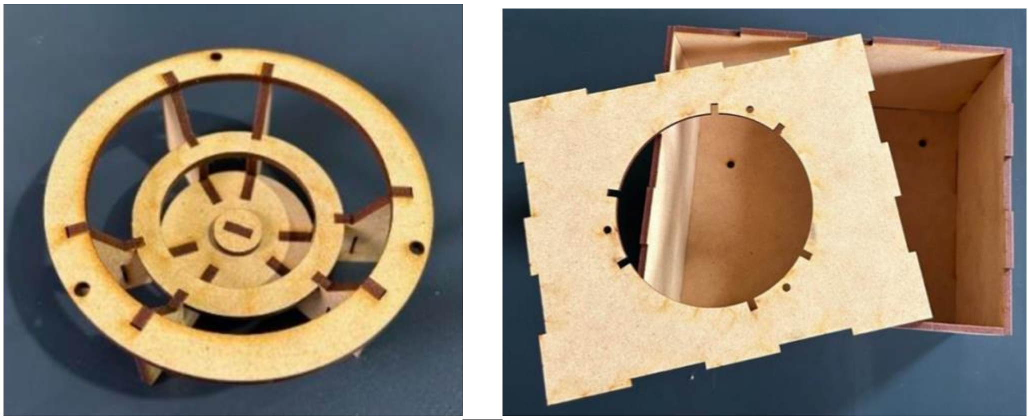

Figure 6: Assembled laser-cut parts: (left) speaker driver chassis, (right) speaker enclosure

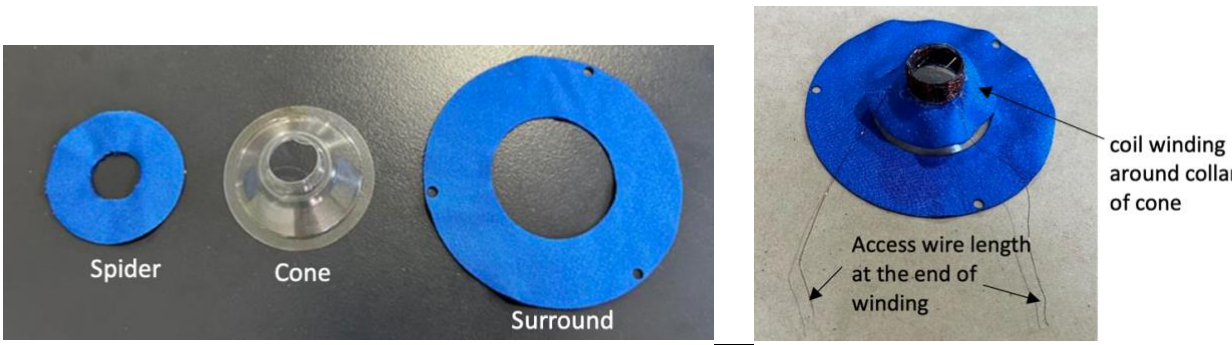

Figure 7: (left) Provided vacuum-formed cone and laser-cut fabric, (right) cone assembly

Students determined the length of their wire by starting with over 3m, using a multimeter to test the resistance, and trimming if necessary. The goal was to achieve a resistance of approximately 8 Ohms, which serves as a lower bound for the impedance.

The cone assembly is then attached to the chassis using glue (only where the spider and surround fabrics touch the chassis). The larger magnet is placed inside the cone, while the smaller is placed underneath at the chassis disc. Their strong attraction keeps them in place, and the speaker driver is finished. A top and side view of the driver and the final enclosed speaker are shown in Figure 8 along with enclosed speaker.

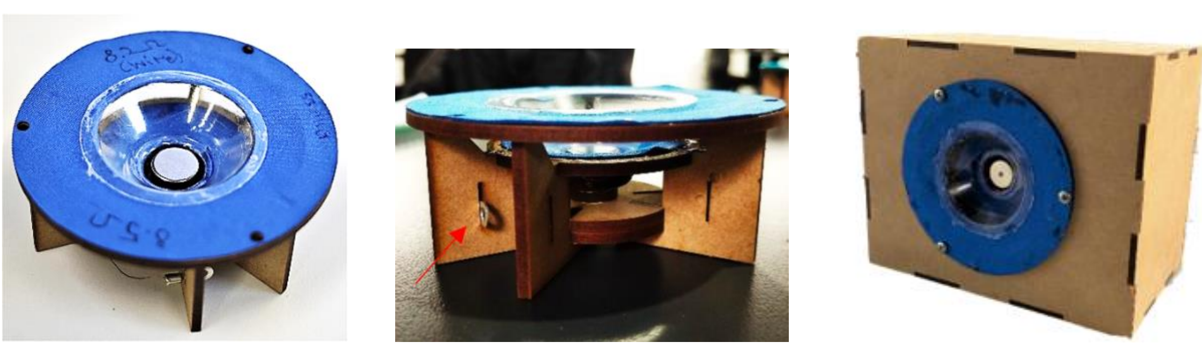

Figure 8: (left) assembled speaker driver, (middle) driver side view, (right) enclosed speaker

An additional enclosure was provided to students which had cut outs for two audio drivers, the DIY driver as well as an off-the-shelf commercial tweeter. Such a two-way speaker allows for better sound reproduction as different audio drivers are better suited to certain frequency bands. As will be seen later, the DIY prototype driver is best classified as a “midrange” driver as it cannot handle very low woofer/subwoofer frequencies, nor does it accurately reproduce the higher frequencies that a tweeter is suited for.

Preliminary Speaker Testing (Week 6)

Bridging the mechanical and electrical aspects of the project was the speaker testing and subsequent design from experimental results. In Week 6, right in between the mechanical and electrical parts of the project, students learned how to perform frequency-domain measurements of sound pressure level (SPL) and determine a baseline impedance of their DIY driver. This not only provided them with valuable data that they would need for the electrical design phase but also served as an intuitive introduction to the frequency-domain.

The following additional items were used for speaker testing (indicative pricing given for some items in USD):

- Dayton Audio iMM-6 measurement microphone (~ $25)
- Commercial tweeter (~ $20)
- Two-way speaker enclosure (from laser cut MDF)
- L-pad attenuator
- 3.5mm male-to-female TRRS cable
- 3.5mm male TRS cable to RCA male (x2) cable
- 2 x 3.5mm stereo female to screw terminals
- Alligator clips and wires
- Breadboard
- Ruler (for measuring distance between speaker and measurement microphone)
- Third Hand Holder tool (for holding up the measurement microphone) (~ $10)
- Protmex P6708 Sound Level Meter (SLM) for initial calibration of SPL (~ $50)[2]
- Digital handheld multimeter
- Acoustic test box (40cm x 40cm x 40cm) with eggshell acoustic foam panels
- Digilent Analog Discovery Kit and accompanying WaveForms software

Speaker impedance is a complex concept for first-year students who may not understand electrical resistance or the idea of it varying with frequency. Nonetheless, a baseline impedance of their prototype driver was important for the crossover circuit design a few weeks later. Students measured the DC resistance of their driver using the Ohmmeter setting of a handheld digital multimeter. This result was compared to an impedance vs frequency measurement performed using the Analog Discovery and the ‘impedance’ function within WaveForms.

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[2] The SLM meter was only briefly needed by each team in each workshop, and therefore only a few meters were available to be shared by up to 16 teams. This was the only item that was shared between teams.

The basic block diagram for frequency response measurements is shown in Figure 9. The free software package Room Equalizer Wizard (REW) [5] was used to both generate the test audio waveforms and process the resulting speaker output captured by the measurement microphone.

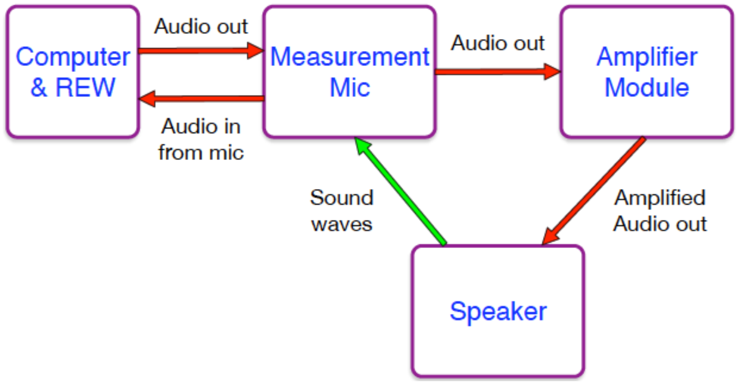

Figure 9: Basic block diagram of sound measurement test setup. Red arrows represent electrical audio signals, while the sole green arrow represents acoustic pressure waves.

Loudspeaker testing is best done in a quiet room or chamber with minimal reverberation time. Due to the scale of measurements being performed (up to 16 teams simultaneously in one workshop class), we had neither a quiet room nor the budget to buy extremely expensive test chambers. We instead built our own relatively inexpensive test box using wood and eggshell acoustic foam panels in the interior (see Figure 10). For best possible testing results, the goal was to both minimize reverberation within and suppress outside noise from coming into the box.

The size of the test box was limited to 40cm x 40cm x 40cm to avoid it becoming unsafe due to being too large and/or heavy. Adding the foam panels inside left limited room between a speaker and measurement microphone. By placing the speaker and measurement mic in diagonal corners, we were able to get a 15cm distance for on-axis testing as shown in Figure 10.

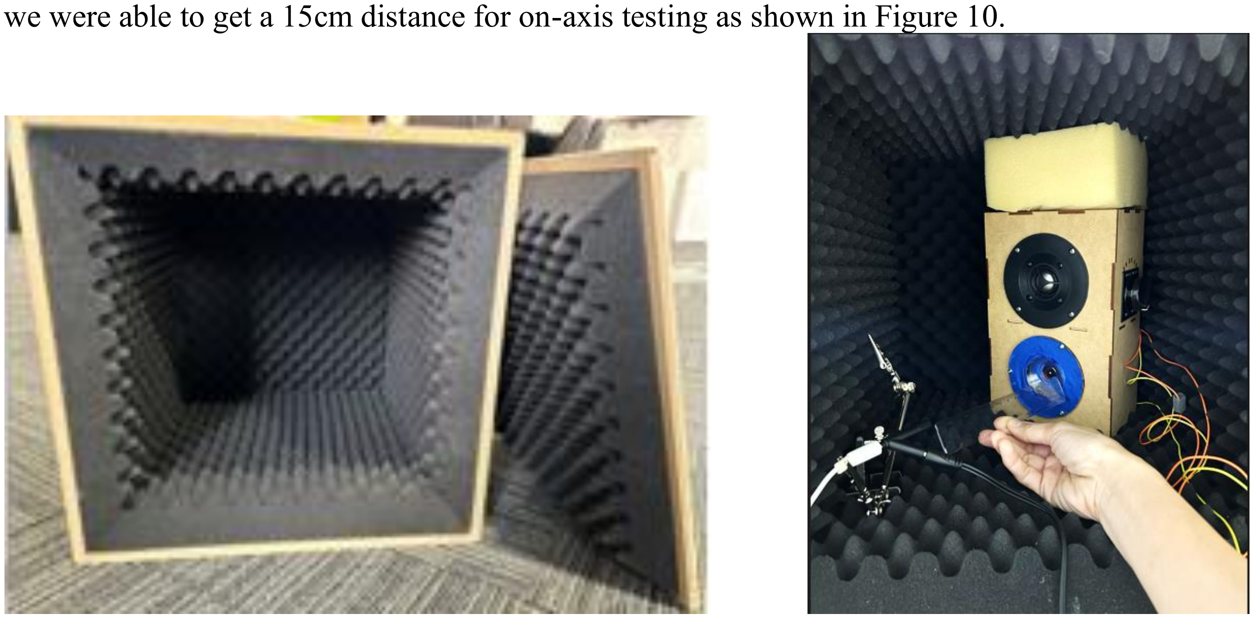

Figure 10: (left) acoustic test box, (right) interior of test box with on-axis testing of the blue driver at a distance of 15cm from the measurement microphone.

Figure 11 shows the setup for separately testing the SPL frequency response of both the DIY speaker driver (midrange) and commercial tweeter in a two-way enclosure. The important concept of calibration was introduced to students as REW receives audio samples with an unknown scaling from the computer's soundcard (external USB) and measurement microphone. Fortunately, REW has a straightforward calibration routine whereby it outputs a test sound that is measured by a SLM meter, and the measured SPL (in dB) then input to REW.

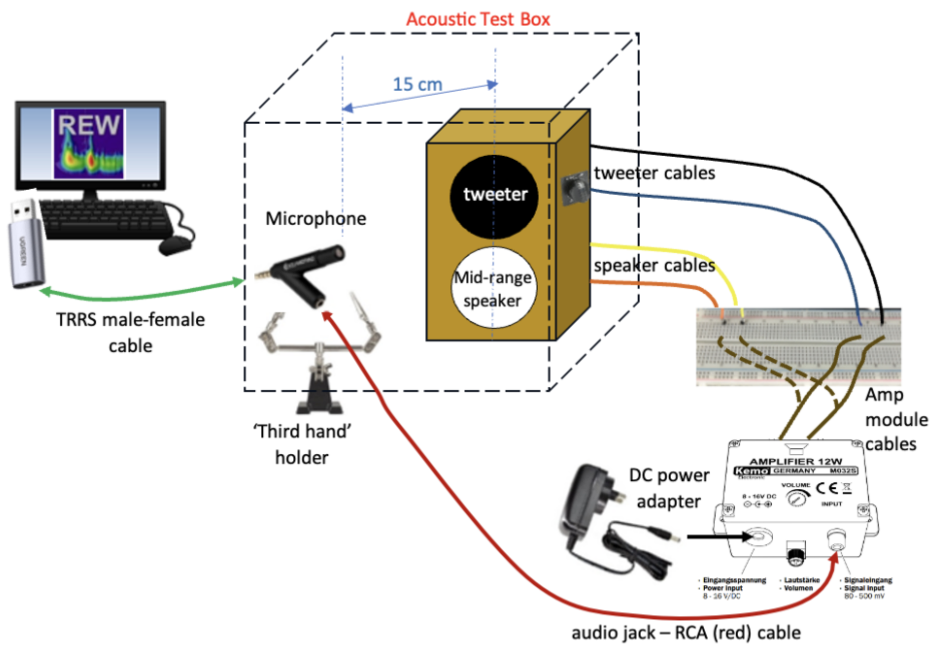

Figure 11: SPL frequency response test setup for individual speaker drivers

A second calibration is needed as the tweeter is louder than the DIY midrange driver.[3] This was fixed using an L-pad attenuator in series with the tweeter to allow students to adjust its volume. Following calibration with the midrange driver only, the L-pad level is adjusted so that the calibration test results in the same SPL as the midrange driver.

Frequency responses of the midrange and tweeter drivers were separately performed, and it was important that the measurement microphone was on-axis with the driver it was measuring at the time. Furthermore, the test box cover needed to be held closed during testing, and students needed to be careful to not to pull any wires and move the Third Hand holder. REW has a Sweep capability whereby a chirp signal (increasing frequency) is played over about 5 seconds, and the measured microphone captures the response and a SPL (dB) versus frequency (Hz) plot results.

Figure 12 shows SPL frequency response results for the DIY midrange and the OTS tweeter in the two-way enclosure. The tweeter response (green) is similar to the one provided by the manufacturer and is flattest from about 2.3 kHz on up. The midrange response (blue) is not a good audio driver as it is not relatively flat over a wide range of frequencies. The ringy results

[3] The DIY midrange driver cannot convert electrical energy to acoustic pressure waves as efficiently as the commercial tweeter made of quality parts.

below 100 Hz are a result of mechanical distortion that was both heard and seen (watching the cone struggle) with tone inputs as test signals. It was clear that such frequencies must be attenuated using electrical filtering for better audio quality and to prevent damage to the midrange driver.

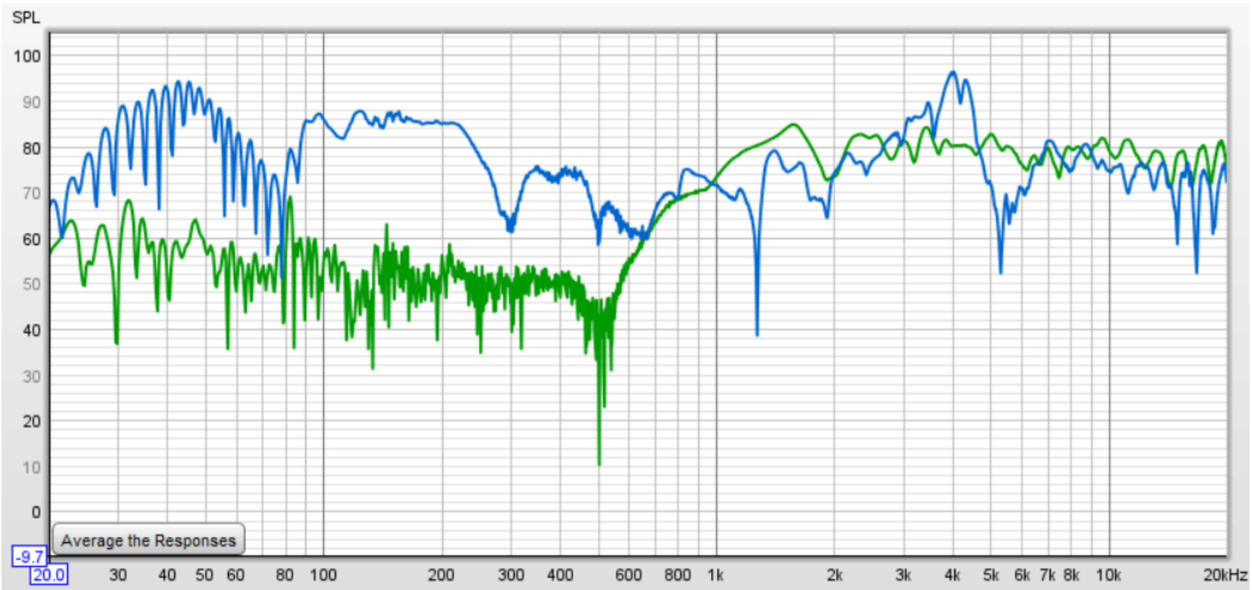

Figure 12: SPL frequency response measurements in dB of the tweeter (blue) and midrange (green) drivers inside of the two-way enclosure

Electrical Design & Implementation (Weeks 7 – 10)

The electrical design part of the project is covered in Weeks 7 – 10 of the semester. No prior knowledge of electrical circuits is assumed for our first-year students, and due to the varied student backgrounds, in-depth theory simply could not be taught. Instead, alternative approaches that abstract away some details were employed. For example, only very basic circuit theoretical concepts (KVL, KCL, voltage division) were taught, while more advanced concepts, such as active and passive filters and op-amps, were taught with a "functional depth". Students were guided through a systems-based approach, whereby filters and a summing amplifier are viewed as basic sub-system blocks that can be designed and interconnected provided loading effects are properly minimized.

The electrical part consisted of building three circuits as shown in Figure 13:

- Circuit #1: a RC highpass filter to remove the lowest frequencies (below 125 Hz or so) from the input audio that cause distortion with the midrange (DIY) driver.[4]
- Circuit #2: a two-band audio equalizer to adjust the sound to a user's preference.
- Circuit #3: a crossover network to send the first few kHz to the midrange driver and the higher frequencies to a commercial tweeter.

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[4] This is due to the quality of the DIY speaker as well as the size of the cone not being large enough to accurately reproduce the lowest frequencies.

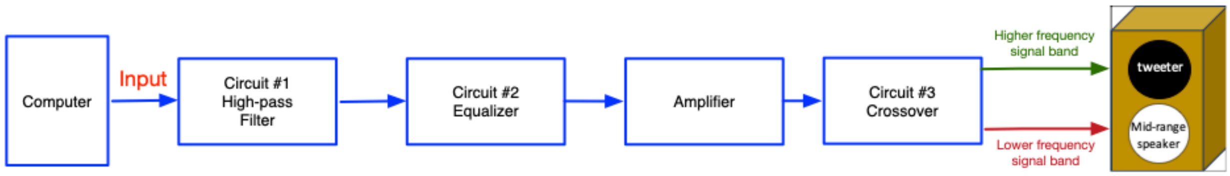

Figure 13: Block diagram showing the electrical parts of the speaker project

Note that the 'Amplifier' block in Figure 13 is the same Kemo M032S amplifier module used in the introductory speaker experiment discussed earlier.

Students were taught the following circuit sub-systems and methods to both understand and implement the three circuits in Figure 13:

- Passive first-order RC filters were needed for Circuit #1 and to split the audio into two bands in Circuit #2.
- An inverting summing amplifier was used to amplify and sum the two signal bands in Circuit #2.
- Trimpots were used as adjustable feed-in resistors of the summing amplifier, thereby allowing the gains of each signal band to be adjusted during operation.
- Buffer amplifiers (also known as a voltage followers) were used to eliminate loading effects between Circuit #1 and #2, as well as within Circuit #2 between the parallel band filters and the gain-adjustable summing amplifier.

While active filters could have directly been used (rather than passive filters followed by a buffer amplifier), passive filters are easier for students to initially understand and breadboard. We also wanted students to understand the important engineering concept that when two individually designed sub-systems are interconnected, their individual performance may be altered by their interaction with each other. Hence, the buffer amplifier was introduced as an in-between sub-system to prevent such problems (loading effects, in this project's case).

Circuit #1 Design

Students use measured frequency response results of their midrange driver to choose a cutoff frequency for the highpass filter in Circuit #1 (shown in Figure 14). The capacitor and resistor values are then computed using basic theory, and due to a discrete range of component values as well as tolerances, students learn they may not be able to achieve the exact cutoff frequency. Students were taught how to cascade first-order passive filters with buffering in between to achieve higher-order filters with better frequency responses. Although it was not required, a minority of teams implemented a second-order highpass filter for Circuit #1.

Circuit #2 Design

The two-band equalizer (Circuit #2 shown in Figure 14) consisted of parallel highpass and lowpass filters with the same cutoff frequency. Students could choose this cutoff frequency based on their test results and listening tastes or go with the 1.59 kHz design that they used in Week 9. Reference values for the two trimpots and feedback resistor R_f were provided, and it was further suggested that a resistor in series be added to limit the maximum band gain and avoid op amp saturation. A minority of teams were able to determine an appropriate resistor value and achieve this.

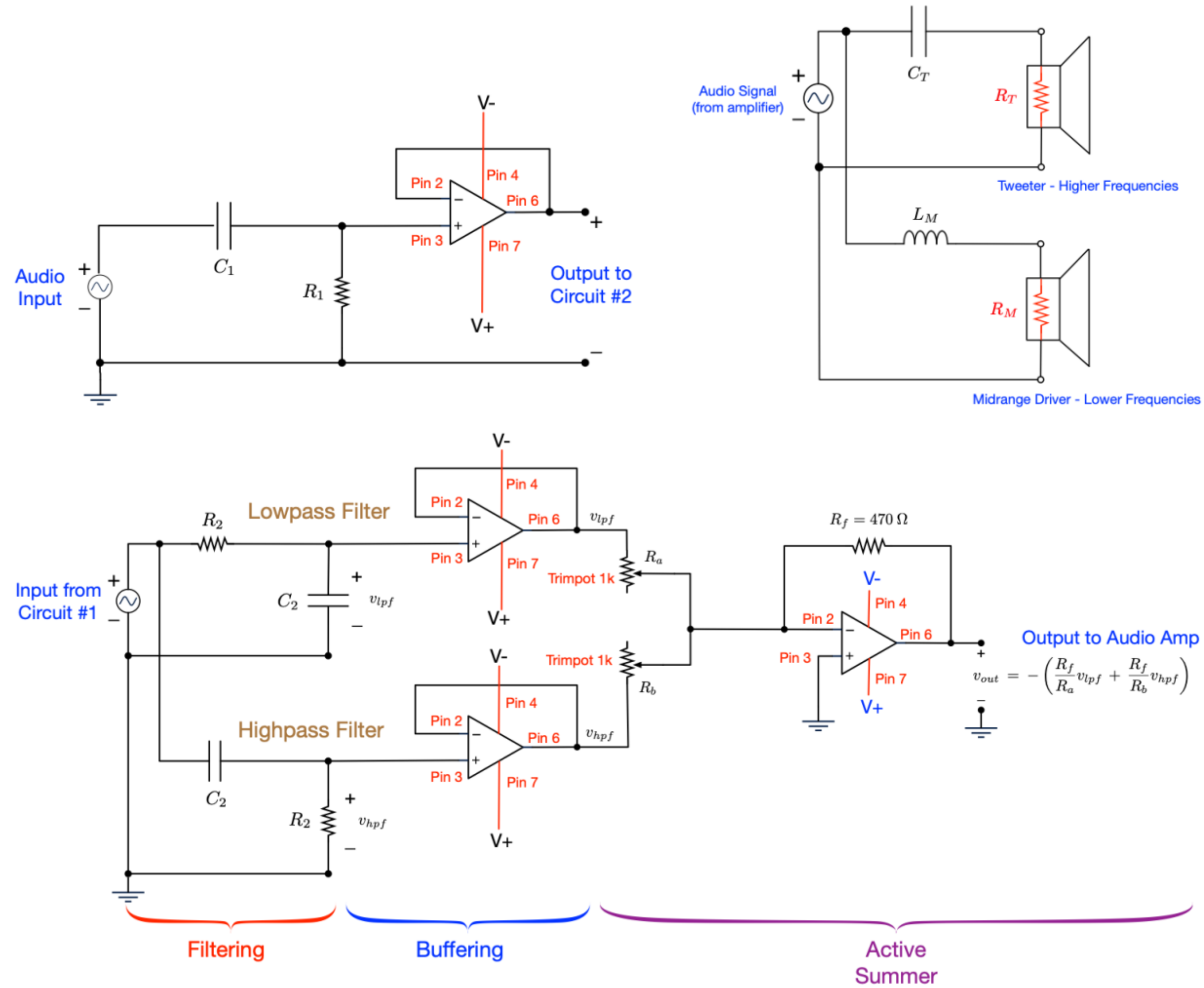

Figure 14: Circuit #1 high-pass filter (upper left), Circuit #2 equalizer (bottom) and Circuit #3 crossover (upper right)

<u>Circuit #3 Design</u>

The purpose of the audio crossover (shown in Figure 14) is to provide the band of frequencies to each driver that they are best suited for. The crossover consists of two parallel first-order passive filters (lowpass and highpass) with a common cutoff frequency that is chosen using experimental frequency response results from their constructed speaker. Circuit #3 was an important learning experience for students for two key reasons:

- The crossover circuit consisted of parallel filters where the each "load" was a component within the filter itself. Hence, there were no loading effects to worry about.
- Students explored the concept of abstraction by modelling a complex device, focusing on the key detail necessary for splitting audio into the two drivers: the impedance of each driver.

Students were taught that choosing a crossover frequency is not an exact science but instead based on eyeballing frequency response results and trying to find a point where both drivers are operating consistently (i.e., more or less flat). In Figure 12, the tweeter is more or less flat starting from about 1.5 kHz. While the midrange isn't flat, it shows a somewhat consistent performance up until about 2.5 kHz, resulting in a crossover (overlap) region of 1.5 kHz to 2.5 kHz for the two drivers. A crossover cutoff frequency should be chosen within this region, and the midpoint (2 kHz) would be a reasonable choice.

In calculating the values of C_T and L_M for the crossover circuit in Figure 14, the impedance of each driver is used along with the chosen cutoff frequency. The tweeter's nominal impedance (8 Ohms) was stamped on the device itself. The midrange's DC resistance measured in Week 6 was used for R_M as it is a lower bound on impedance (which varies with frequency). Along with a chosen crossover frequency f_{CO}, the two reactive components are calculated as $C_T = 1/2\pi f_{CO} R_T$ and $L_M = R_M/2\pi f_{CO}$.

Circuit Implementation
The following components were made available to students to design their electrical circuits:

- Resistors (various values)
- Capacitors (various values)
- Inductors (various values)
- 741 Op Amps (for buffer and summing amplifiers)
- Trimpots (for adjusting equalizer levels)
- Breadboards
- Jumper wires (as well as wire they could strip and cut to a desired length)

Students learned how to build simple series circuits on a breadboard from a schematic, but from the experience of project's first running in 2022, more complicated interconnected circuits (e.g., the equalizer) were too difficult for students to do such "free-form" breadboarding.[5] Significant amounts of time were spent on debugging poorly constructed circuits, which unfortunately took away from other aspects and learning objectives of the project. We subsequently changed to a sub-system templating approach [6] in 2023, whereby students only free-formed simple RC low-pass or high-pass circuits, while all other connections were given in a breadboard diagram for them to copy. This resulted in significantly less breadboarding problems, but there were still a few teams that really struggled and needed a good deal of help.

Students learned to use the Analog Discovery kit along with the software WaveForms to provide voltage inputs and measure their circuit responses in both the time and frequency domains.

Integration, Testing, and Final Demonstration (Weeks 11 – 12)

The workshop in Week 11 is dedicated to the integration, testing, and debugging of the complete speaker system before the final demonstration in Week 12. Students needed this time to fix any problems and make sure everything was working correctly. Figure 15 shows the complete speaker test system with all three circuits and the two-way speaker.

[5] By "free-form" breadboarding, we refer to the typical constructing of a circuit from a schematic onto a breadboard without any sort of breadboard diagram to copy from.

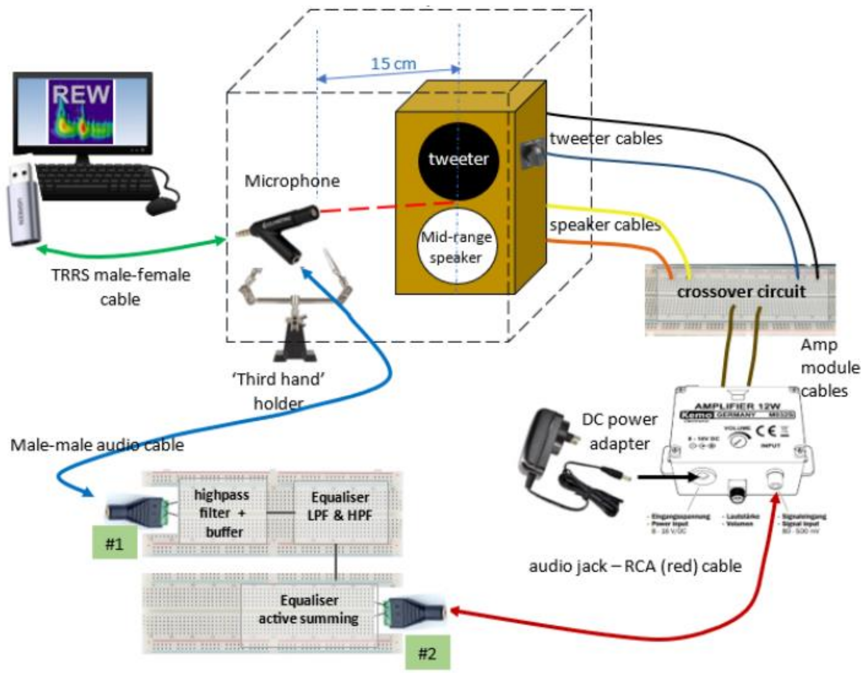

Figure 15: Complete speaker system for final demonstration

Each team was required to submit a complete a demo template document giving all component values, schematics and various frequency response results (speaker SPL results and electrical responses of Circuit #1 and Circuit #2) prior to their demo day in Week 12.

The demo assessment was done at three separate stations in the workshop room. The first station had an academic look over the mechanical design drawings and the constructed DIY driver and students were asked questions. The second station had an academic go through the demo template document with a team, look at their breadboard and ask them questions. The third station had students perform four separate REW testing scenarios of the speaker system as well as listening of the results. The four scenarios were:

1. Separate midrange and tweeter SPL plots without any of the three electrical circuits.
2. Separate midrange and tweeter SPL plots with Circuit #1 (highpass filter).
3. Overall two-way speaker SPL plot with Circuit #1 and Circuit #3 (crossover)
4. Overall two-way speaker SPL plots with all three electrical circuits

The audio testing assessed the team's procedure and results in several ways. For example: Was calibration was done properly? Does the highpass filter appear to be attenuating in the second scenario compared to the first? Does adjusting the equalizer affect the frequency response as it is supposed to?

Reflection and Discussion

The speaker project has been quite challenging, both on staff and students, in its first three offerings to date. The first offering had planned to use 3D-printed parts for the driver chassis and cone, but shortly before the start of semester, our maker space informed us that it would be impossible timewise for all 50+ teams to fabricate their parts in the same week or two. We instead 3D-printed parts for the chassis in advance for students and pivoted to a vacuum-formed PETG cone that performed better. Students were still required to show valid 3D-CAD drawings based on the reference design sheets.

This switch to the laser-cut chassis in the second offering was simply out of need to significantly reduce fabrication time so that all teams could finalize their SolidWorks drawings by Week 4 and have a DIY driver ready for testing in Week 5. The circuit templating approach [6] also was introduced that same semester in addition to a reduction from four electrical circuits to three.[6] These changes improved the project and student experience, but there were still some teams that struggled with breadboarding/debugging the equalizer and/or performing audio measurements.

Drawing, fabricating and building a working speaker is the most straightforward and tangible part of the speaker project. Almost every team was able to do this to a minimum standard. On the electrical side, Circuits #1 (highpass filter) and #3 (crossover) are the more achievable tasks, while the equalizer is the most difficult part of the project and causes some teams a lot of problems. While we could revert entirely to a "copied diagram" approach for breadboarding to make things easier, it would hurt the learning experience of students looking for a challenge and to develop circuit-building and debugging skills.

One tricky part with the audio testing is that results varied from team to team. Various factors causing this include subpar wrapping of the voice coil, improper fitting and assembly of the laser-cut parts, and poor alignment of the cone assembly glued into the chasses. Whereas we provided a detailed construction document and close-up video, there were still problems that may be attributable to lack of patience or a rush job before the audio testing workshop in Week 6.

One significant problem we encountered in the first semester was students transporting their DIY driver and damaging it. We did not use Molex ring terminals and teaching assistants did the soldering for the students. We had numerous cases of broken solder points or broken copper wires, and students would come to the workshop and find out their driver was not working. This prompted the shift to using Molex ring terminals and having students go through the proper training and be responsible for their own soldering at the maker space.

While the overall student experience has progressively improved over the three offerings, student feedback has been mixed. Some students have found the project to be a great experience, while others have struggled and felt the opposite. Feedback from our teaching assistants, who work closely with the teams, is that students without sufficient high school physics (particularly electricity and magnetism) have clearly been those that struggled the most. For the next offering, we are planning to let students know this before they list their preferences for which one of the three projects they do for the course.

[6] The fourth electrical circuit was a stereo-to-mono active summer that added the left and right audio channels before the highpass filter (Circuit #1). This was removed as the circuitry was perhaps too much, and now only the left audio channel is played by the speaker.

Conclusion

This "Bring Your Own Experiment" (BYOE) paper highlighted a project-based approach to engineering education through an innovative DIY speaker design project. By engaging first-year students in a hands-on, multidisciplinary experience through building their own speaker system, students engage with engineering fundamentals in a tangible way, sparking curiosity and providing a stronger foundation for their future engineering education. Through the project, students not only gain a deeper understanding of both mechanical and electrical engineering principles but also develop essential teamwork and problem-solving skills. The project has been iteratively improved over three semesters, underscoring the importance of adaptability and continuous improvement in project-based curricula. This paper serves as a resource for educators looking to implement similar projects in their curricula and could be adapted in a number of ways – for example if a course needed a shorter project of five weeks or so, the mechanical part plus a week of audio testing could work well.

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