CSE 237D Spring 2025

TONIQ Milestone Report

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1. Project Milestone Report

TONIQ is in the process of assembling a complete functional prototype of our TONIQ water bottle. After a tumultuous few weeks, we have managed to get the E-Ink Display working, have a close to final mechanical design model, have prototype breadboards and firmware for all our sensors, and are working on designing a PCB.

2. Progress

2.1. Addressing Feedback

The feedback we received from the project proposal fell into three categories: (1) our compact timeline, (2) teammate accountability, and (3) component testing.

2.1.1. Timeline

We set an ambitious timeline to make a working, polished product this quarter. This goal required setting quick turnaround times and parallelizing tasks. We decided to slightly modify our timelines to make more slack to account for unforeseen issues. For example, our e-ink display sample code was not working, we had to use third party code to get it to work. We then had to port the sample code from Arduino to our more power efficient Nordic MCU. Furthermore, we discovered that our "flexible e-ink display" *does not function* when bent at any angle. This set back our timeline by another week. This unexpected issue forced us to change our display and change our entire mechanical design last-minute before finalizing our PCB.

Secondly, we had many complication with designing a robust mechanical design that can house our feature set, fit standard water bottle sizes, and is water proof. We iterated on our design over a dozen times. We worked to revise our lid design for 3D printing so that it meets the tolerances to fit our curved display and thread onto our demo Hydroflask. This design was complex because we needed to make sure that it is feasible to assemble the lid, fit all the electronics, and route the power and display ribbon cables through the interior of the 3D print. In addition, our ultrasonic and TDS sensors need to be able to interact with the user's liquid. We prototyped different materials for the TDS sensor to poke through the lid while still accurately sensing the water's TDS ppm. We had to figure out how to deal with the main functionality of measuring water level over time. We compared every available sensor and decided to keep our initial choice of an ultrasonic sensor. We had a few issues with existing ultrasonic boards: they are too large for our lid and the acoustic membrane is neither food-safe nor waterproof.

We solved the size constraint by making a custom PCB. We prototyped with a waterproof ultrasonic board, but did not find that it would be food safe. We settled on boosting the voltage to the speaker of the ultrasonic sensor and tested that it should be able to receive enough signal back to determine the water level through a thinned section of our plastic lid.

2.1.2. Teammate Accountability

Our groupmates know each other, so we knew that we can hold each other accountable to deadlines. We found that being truthful about our schedules and committing to get things done in our group chat has worked. This transparency has let us ensure fairness of work allocation.

2.1.3. Design Qualification

Lastly, Professor Kastner expressed doubts about our plans to test individual components. We created specific tests we needed to breadboard before integration. We separated tasks to write drivers for each hardware component and get ti working with its own firmware and breadboard. This independence enabled us to parallelize tasks. We used this separation to make sure the hardware works as expected, such as the ultrasonic sensor and TDS module. We do not have plans to test the UV-C LED due to the safety implications of handling the LED. We need to make all the firmware bug-free and implement safety mitigations to ensure the LED can only turn on when the lid is closed. As far as development, we confirmed the UV-C LED works the same as a normal LED, which is how we are prototyping.

3. Group Management

3.1. Accomplishments per Person

Over the course of the last few weeks, the group managed to balance collaboration between members alongside the strengths of individual contributions. We split up into sub-groups to handle larger undertakings while delegating smaller tasks to individuals. Most of our work was done during long chunks of time set aside for project work. We believe that working together in person on the project is most effective hence why we frequently pair up on more complicated tasks.

On the mechanical side, we had Cody and Samir focus on the early iterations of the 3D model of the lid. This involved several cycles of prototyping to determine the best form factor to accommodate placement of sensors, maintain compatibility with existing water bottle bases, and be able to fit any additional electronics. Later on, Cody made a few more rounds of adjustments to ensure that the lid perfectly fits any wide-body water bottle.

For software, we've made solid progress in showcasing the capabilities of each of our water bottle's components. We split up the software work into a few isolated pieces before focusing on integration. Anthony and Samir focused on implementing firmware for our TDS (Total Dissolved Solids) sensor, which is responsible for measuring the water quality. This involved sampling data from an ADC (Analog to Digital Convertor). Samir also focused on writing the firmware for the ultrasonic sensor, which is responsible for measuring the water level. Anthony was able to read gyroscope data from our IMU over I2C to determine if the water bottle is upright as opposed to moving around (i.e. in a backpack). Kyle lead development of the e-ink firmware development with the help of Samir and Anthony. Initially, the three of them were focused on getting simple SPI transaction working (without the display). This proved to be more difficult than anticipated; we found example code provided from a third party that worked on an Arduino. Within a couple hours, we had our e-ink display finally showing text on the screen. Unfortunately, we later discovered that the e-ink display cannot physically refresh when bent, despite being advertised as flexible.

Electronics are in an earlier stage than the rest of the project. Cody has been hard at work with sourcing electrical components for our PCB. He also has started the PCB schematic with a few components completed already.

4. MVP/Milestone Completion

Listed below are the milestones we set out to complete on/before May 18th, along with their current status, applicable deliverable, and the team member(s) that completed it.

Milestone	Status	Deliverable	Team Member
Initial bottle lid designed in CAD + 3D printed	Complete	Presented in oral project update (see slides on Canvas)	Cody
MCU + sensors selected, water level monitoring implemented	Complete	Link to BoM; see GitHub for ultrasonic sensor progress	Cody
Firmware drivers for e-ink display, TDS sensor written	Complete	GitHub Link	Kyle Anthony Samir
Display UI designed, PCB designed + ordered	In Progress	Image Link	Kyle Anthony Cody

Milestone	Status	Deliverable	Team Member
MVP complete using dev kits + finalized 3D print model	In Progress	Presented in oral project update (see slides on Canvas)	Cody Anthony Kyle, Samir
Firmware for BLE connection to smartphone health app written	Abandoned	N/A (see explanation below)	N/A

With regard to the BLE connection firmware milestone, we have primarily been focusing on implementing the functionality contained within the bottle lid. Although this would be an interesting feature to add at some point in the future, we believe it is out of the scope of this class. Therefore, we are removing it as a target milestone for the final deadline.

5. Updated Project Milestones

Week	Milestone	Priority	Date
7	Finish debugging e-ink hardware and start PCB design	10	(5/18)
8	Finish e-ink firmware on nrf52840 and order PCB	8	(5/25)
9	Integrate all the sensor readings and implement display graphics	6	(6/1)
10	PCB assembled + integrated into bottle; end-to-end testing	9	(6/8)
Finals	Final video + presentation + report complete	10	(6/9-6/13)

6. Gallery

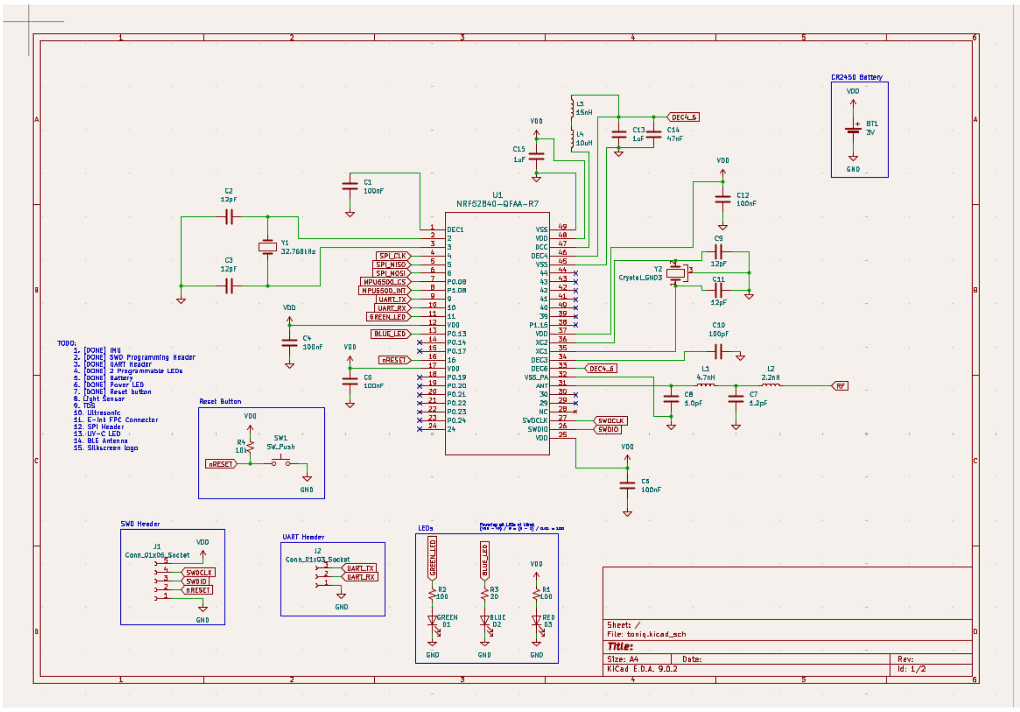
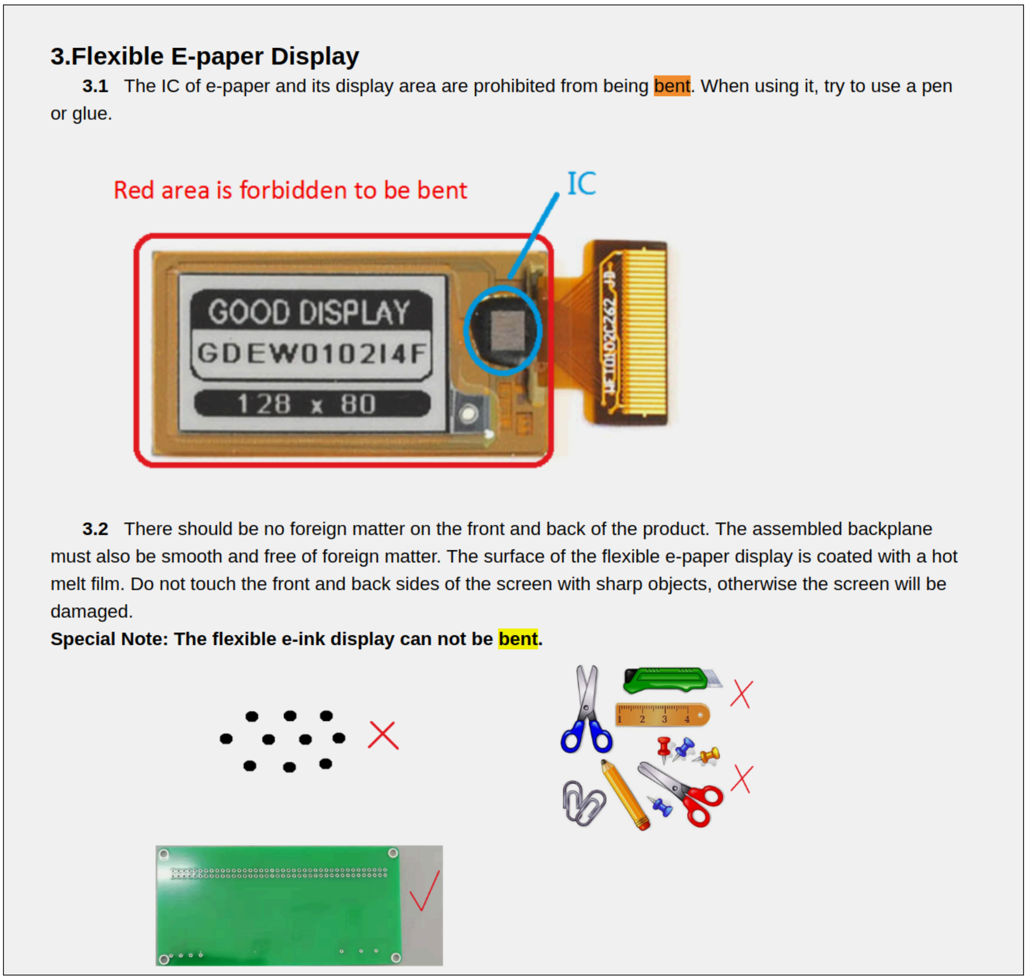


Figure 1: Initial TONIQ PCB schematic



3.Flexible E-paper Display

3.1 The IC of e-paper and its display area are prohibited from being bent. When using it, try to use a pen or glue.

3.2 There should be no foreign matter on the front and back of the product. The assembled backplane must also be smooth and free of foreign matter. The surface of the flexible e-paper display is coated with a hot melt film. Do not touch the front and back sides of the screen with sharp objects, otherwise the screen will be damaged.

Special Note: The flexible e-ink display can not be bent.

Figure 2: Screenshot of E-ink manufacturer's website that shows the "red" area of the "flexible" e-ink display which cannot be bent

Figure 3: Most recent versions of our 3D model in OnShape

Figure 4: Prototype of our 3D printed lid with a TDS sensor inserted at the top

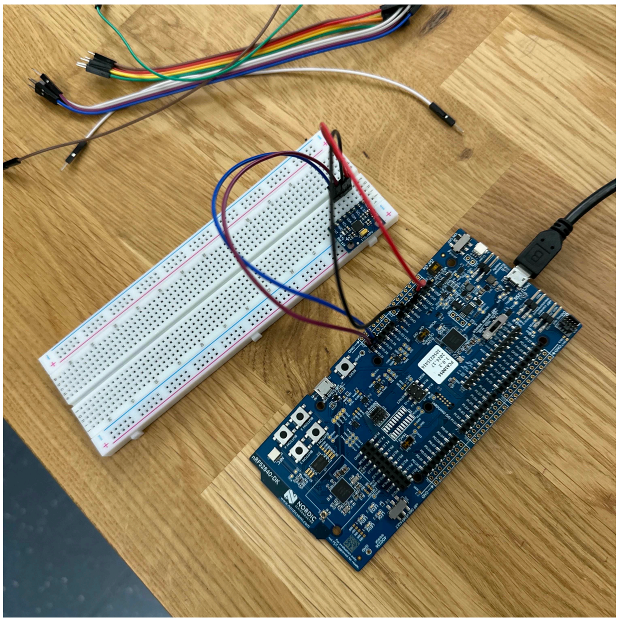


Figure 5: Development of IMU using the breakout board

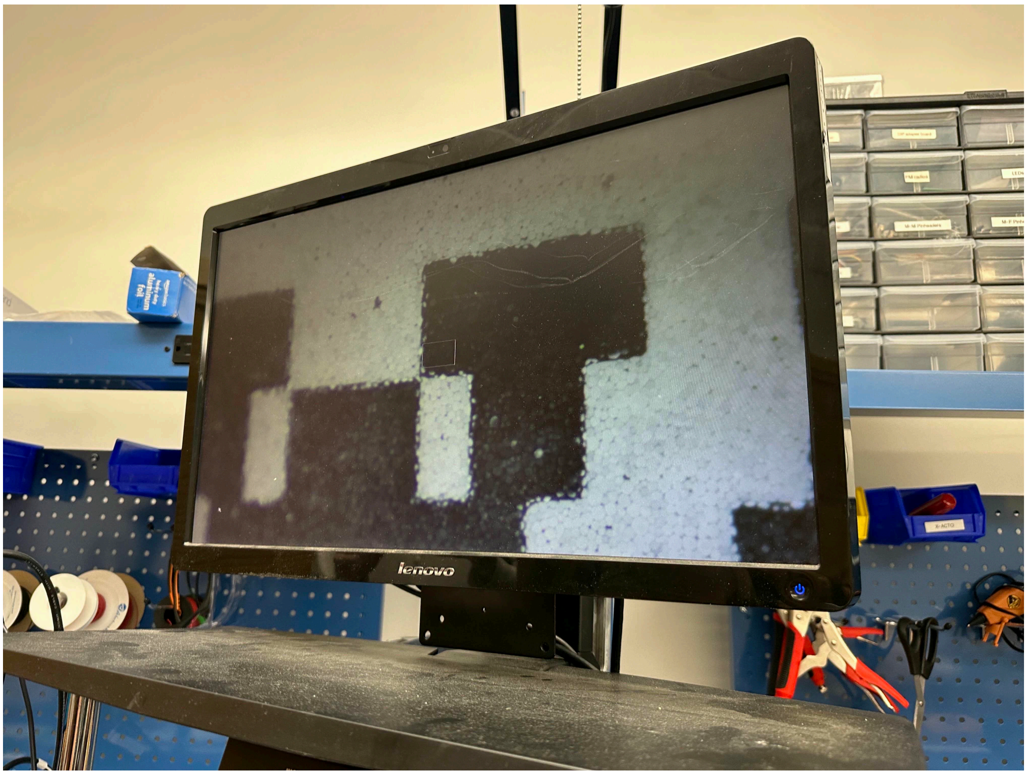


Figure 6: Examining the material composition of the e-ink screen under a microscope

Figure 7: Samir explaining where the battery will be placed to Cody and Kyle

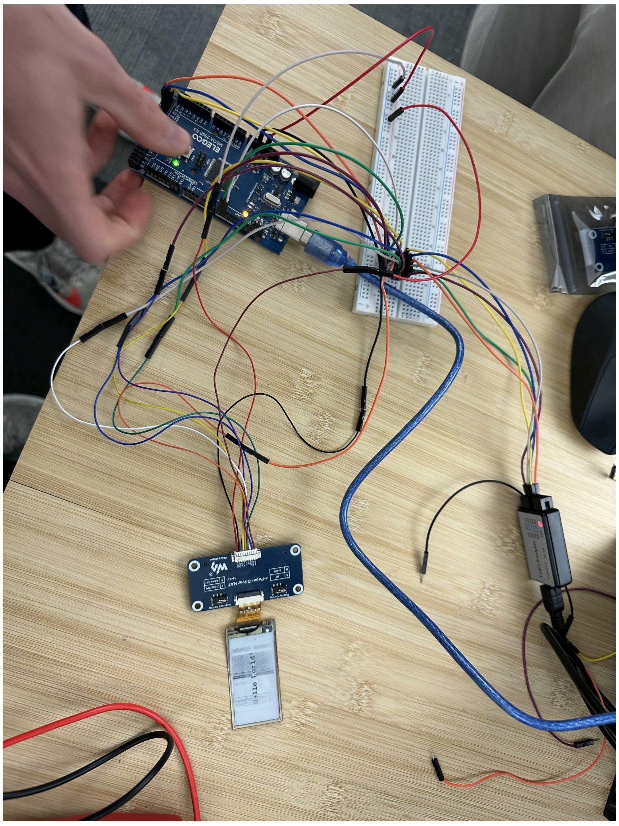


Figure 8: Mess of wires while debugging the e-ink display using a logic analyzer

Figure 9: Working display (top left), broken display (bottom left), new display (center), rough sketch of the UI (right)

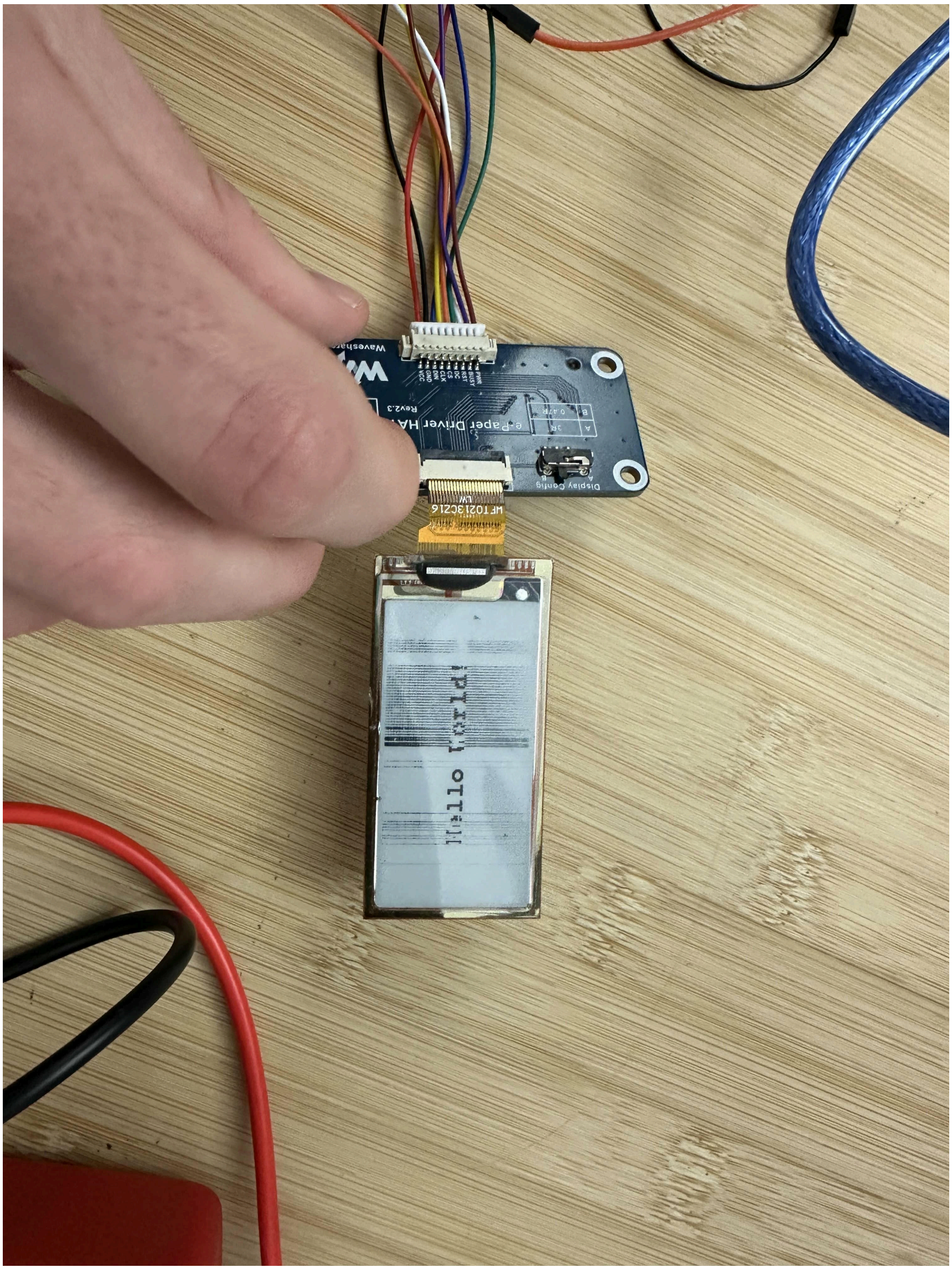


Figure 10: The first flexible e-ink screen we purchased which was damaged due to being bent too much

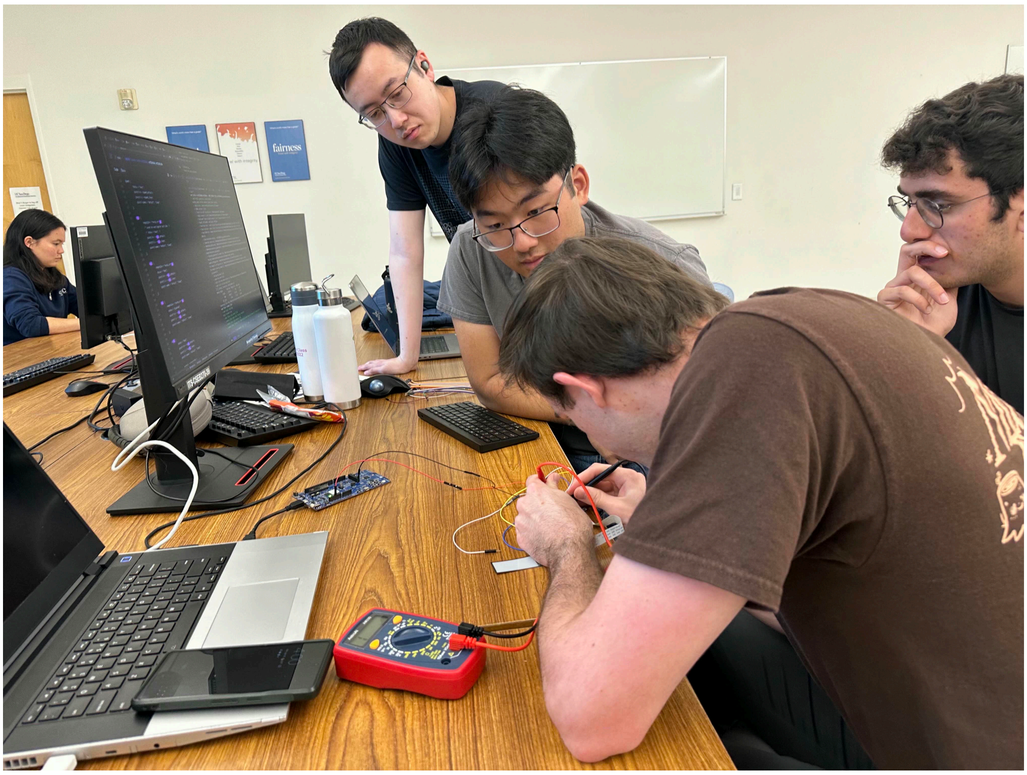


Figure 11: The team testing if the display is actually functional. Also pictured is our friend observing the process.