

FRAMEWORK FOR REMOTE LABS

Virtual Interactive
STEM Teaching Aid

Team VISTA



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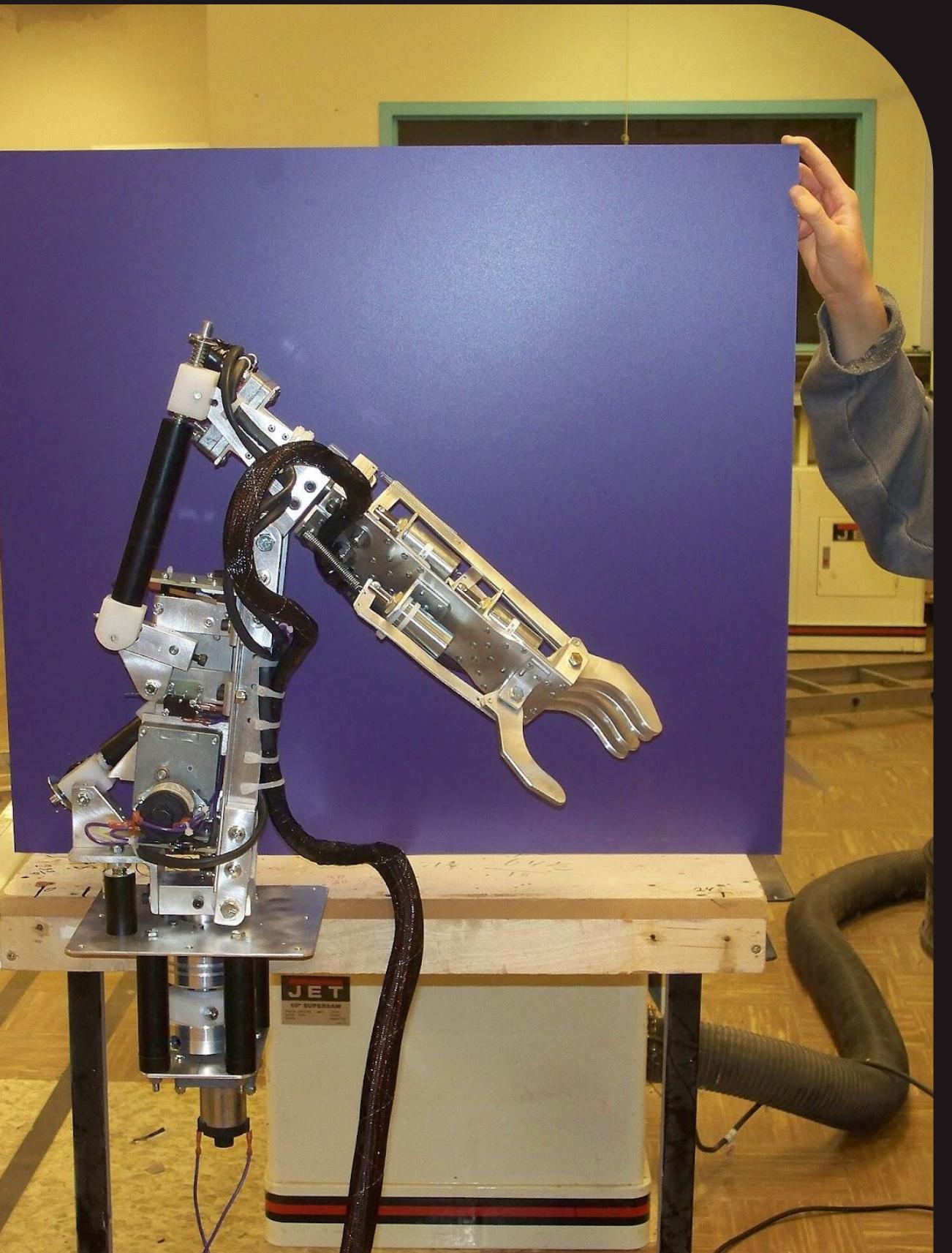
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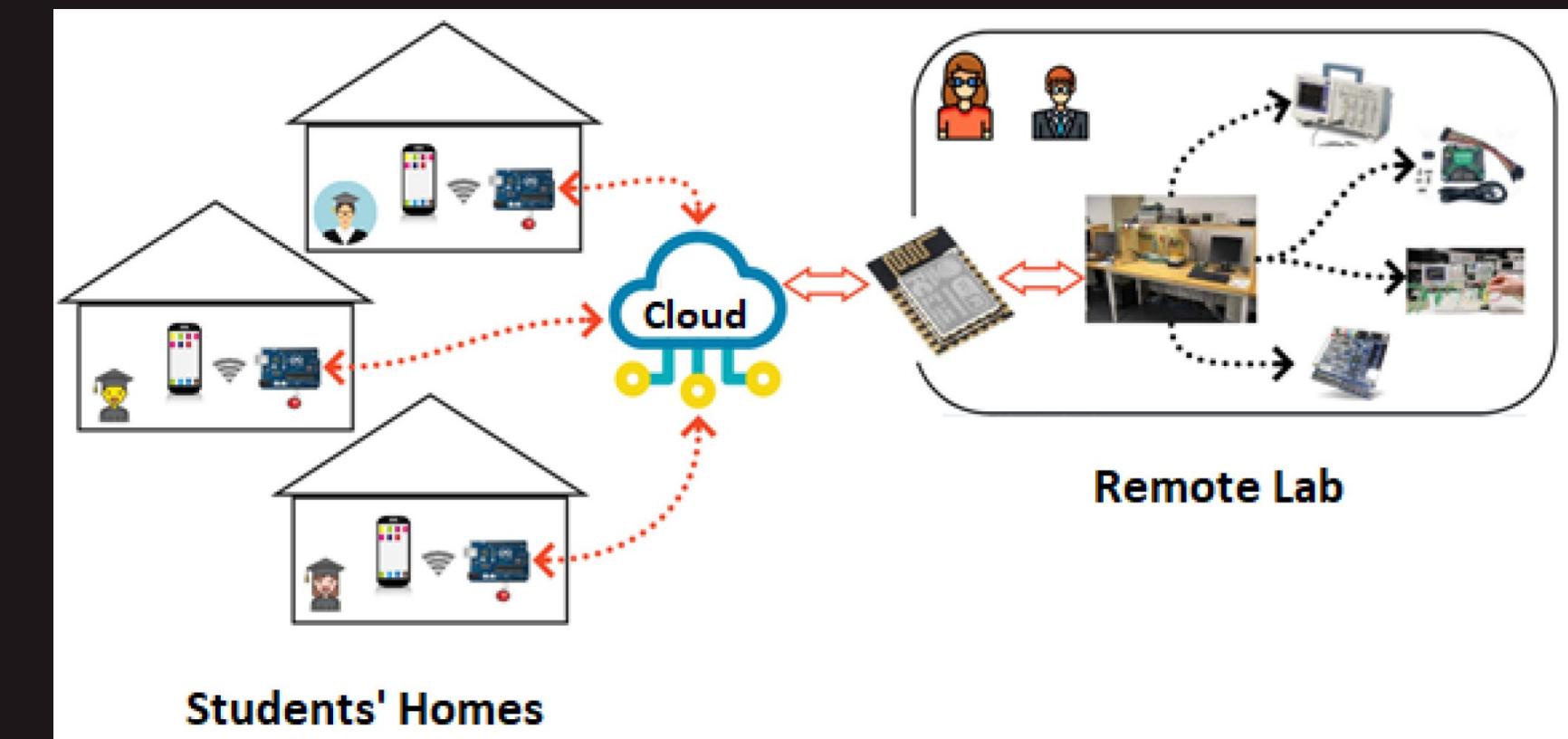
INTRODUCTION

- Traditionally in-person lab → remotely manipulated lab
- User-friendly interfaces
- Improve accessibility
- Allow students to work with potentially hazardous materials



WHY REMOTE LABS?

- Accessible Learning
- Effective Learning
- Financial Accessibility



Students' Homes

EXISTING REMOTE LABS

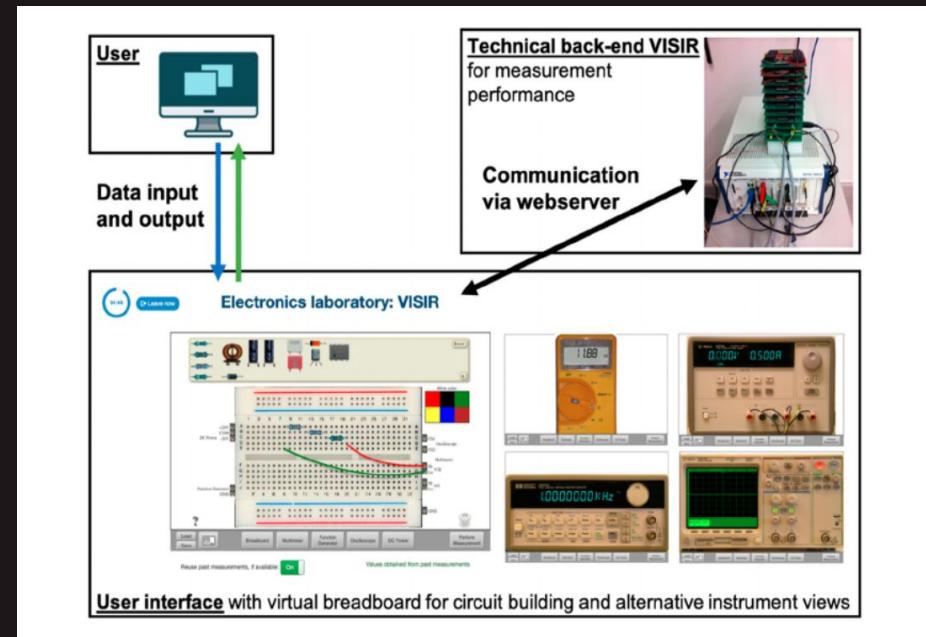
Overview:

- Real equipment, remote access
- Safety & accessibility
- Skill development

Challenges:

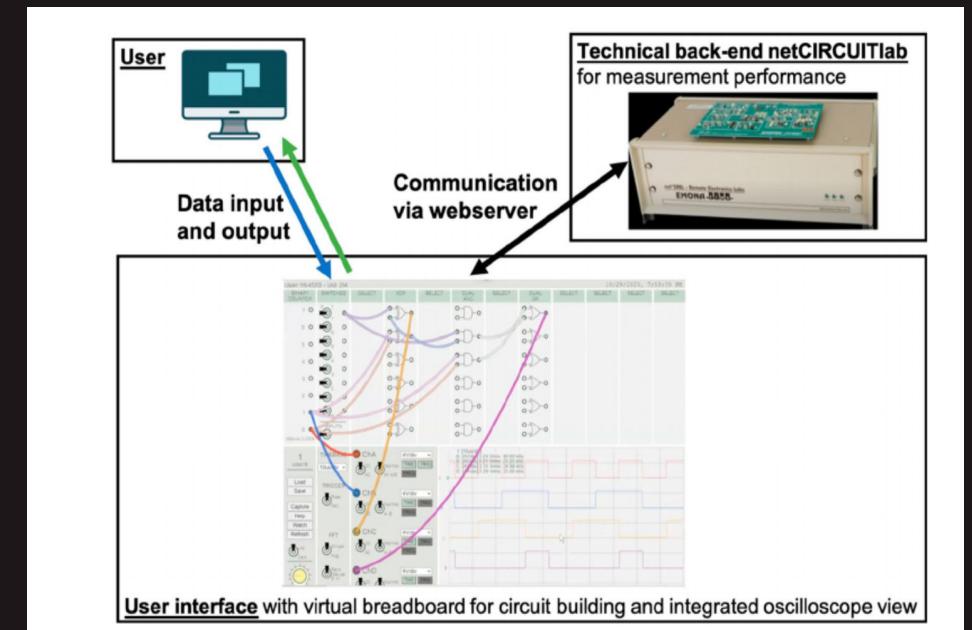
- Dependence on internet connectivity
- Potential logistical and technical issues
- Complex setup
- Expanding past topic of electrical circuits

VISIR Labs: Electrical Circuits



Structural overview of the VISIR remote lab [3]

netCIRCUITlabs: Electrical Circuits

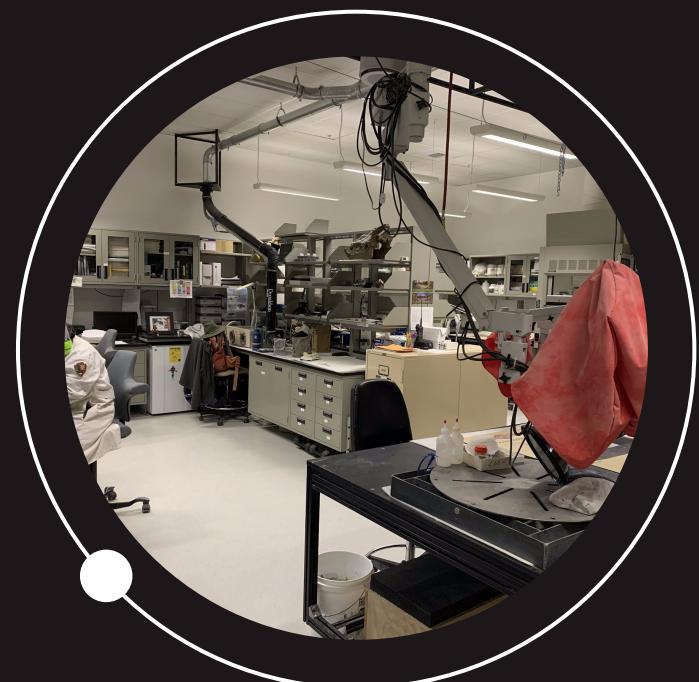
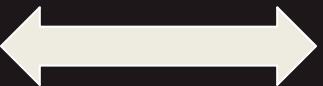
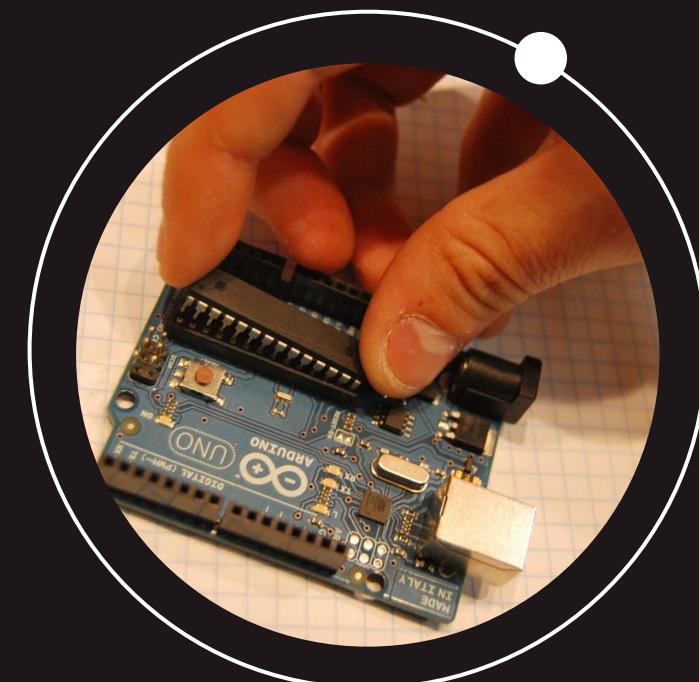
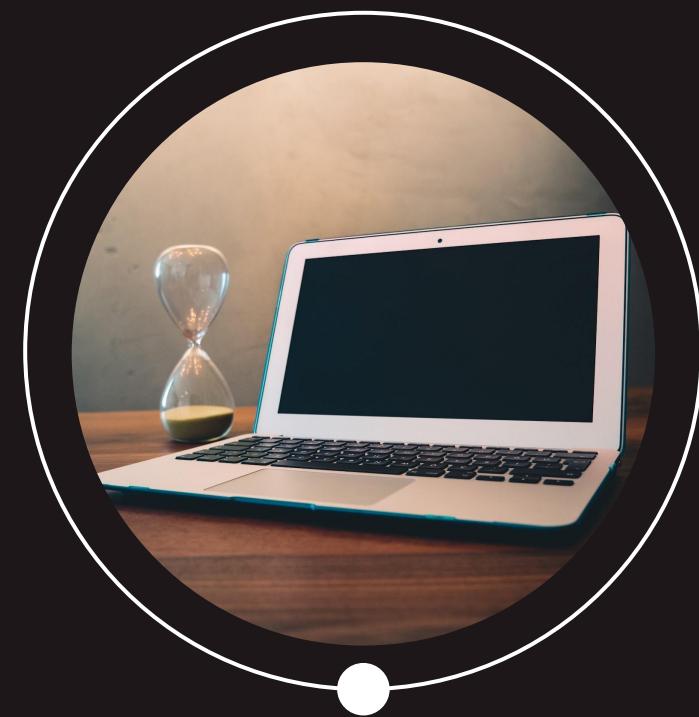


Structural overview of netCIRCUITlabs remote lab with user interface and technical back-end [4]

RESEARCH QUESTION :

How can traditionally in-person labs be evolved into remote labs to improve accessibility?

THREE INTERFACES



Interface 1

User Interface:
User view and control of
the lab [5]

Interface 2

Connecting Interface:
Software communicating between
user and lab [6]

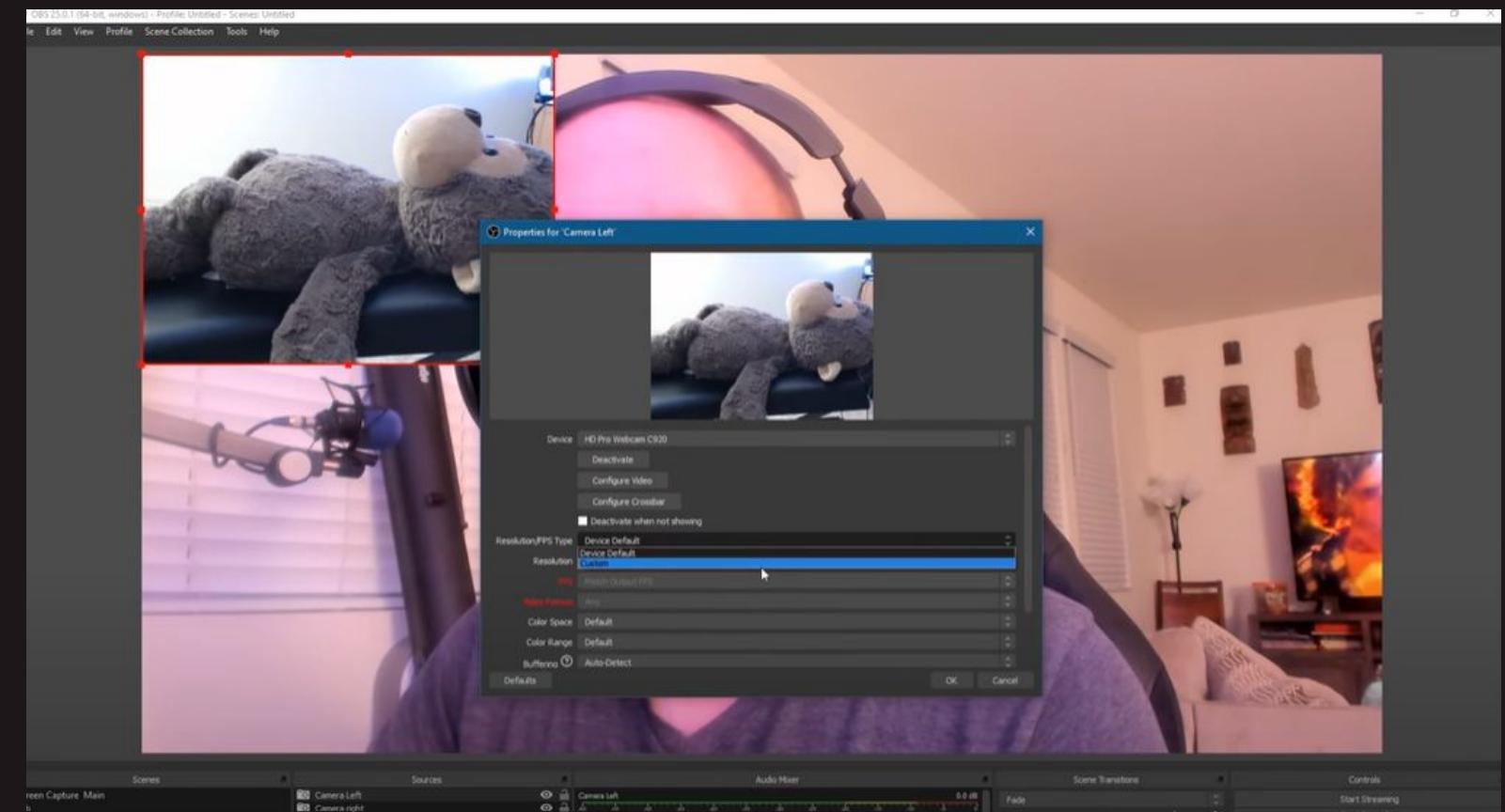
Interface 3

Lab Interface:
Physical control of the
lab [7]

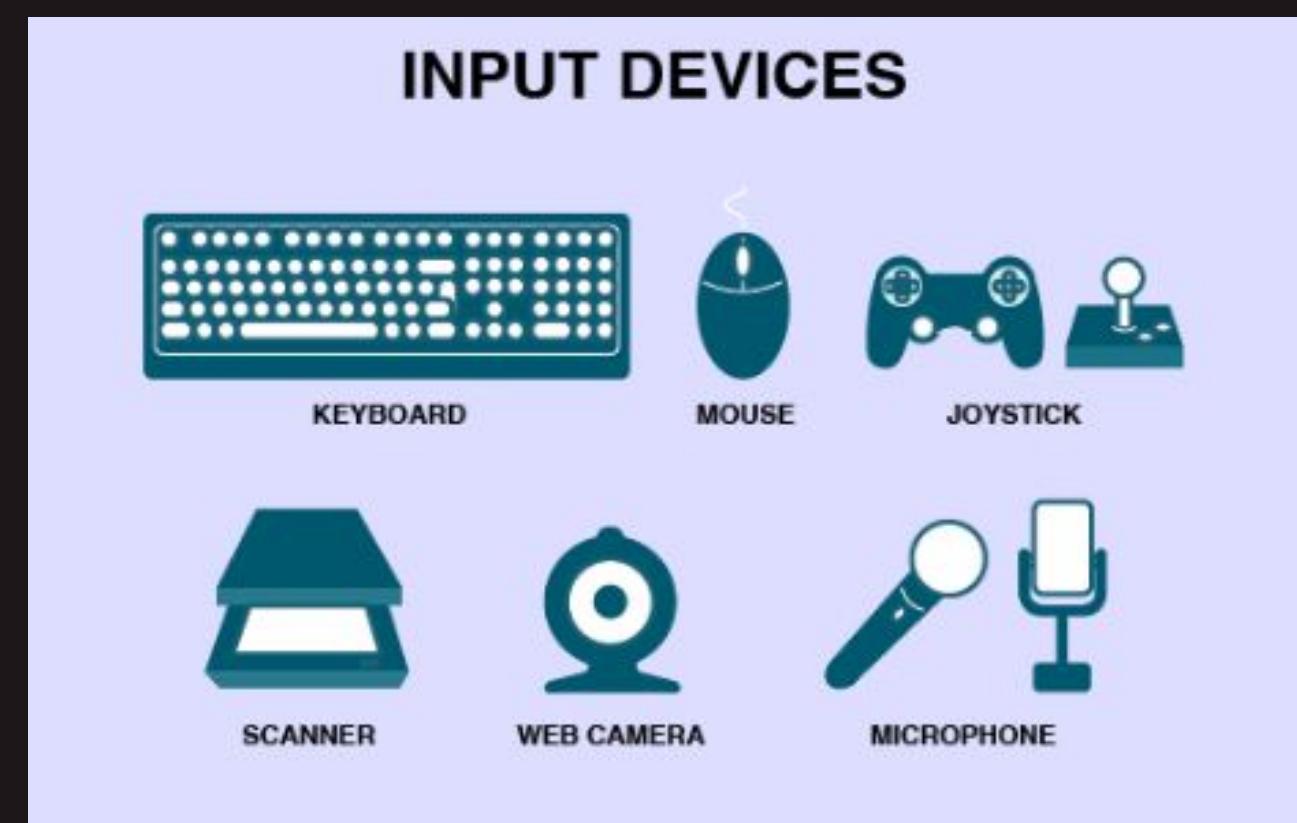
INTERFACE 1: USER INTERFACE

Purpose & Goals: The Graphical User Interface

- Simple web-based platform
- Users will be view the entire lab via a video stream
- Interaction with the lab will be performed using input devices like keyboards and game controllers



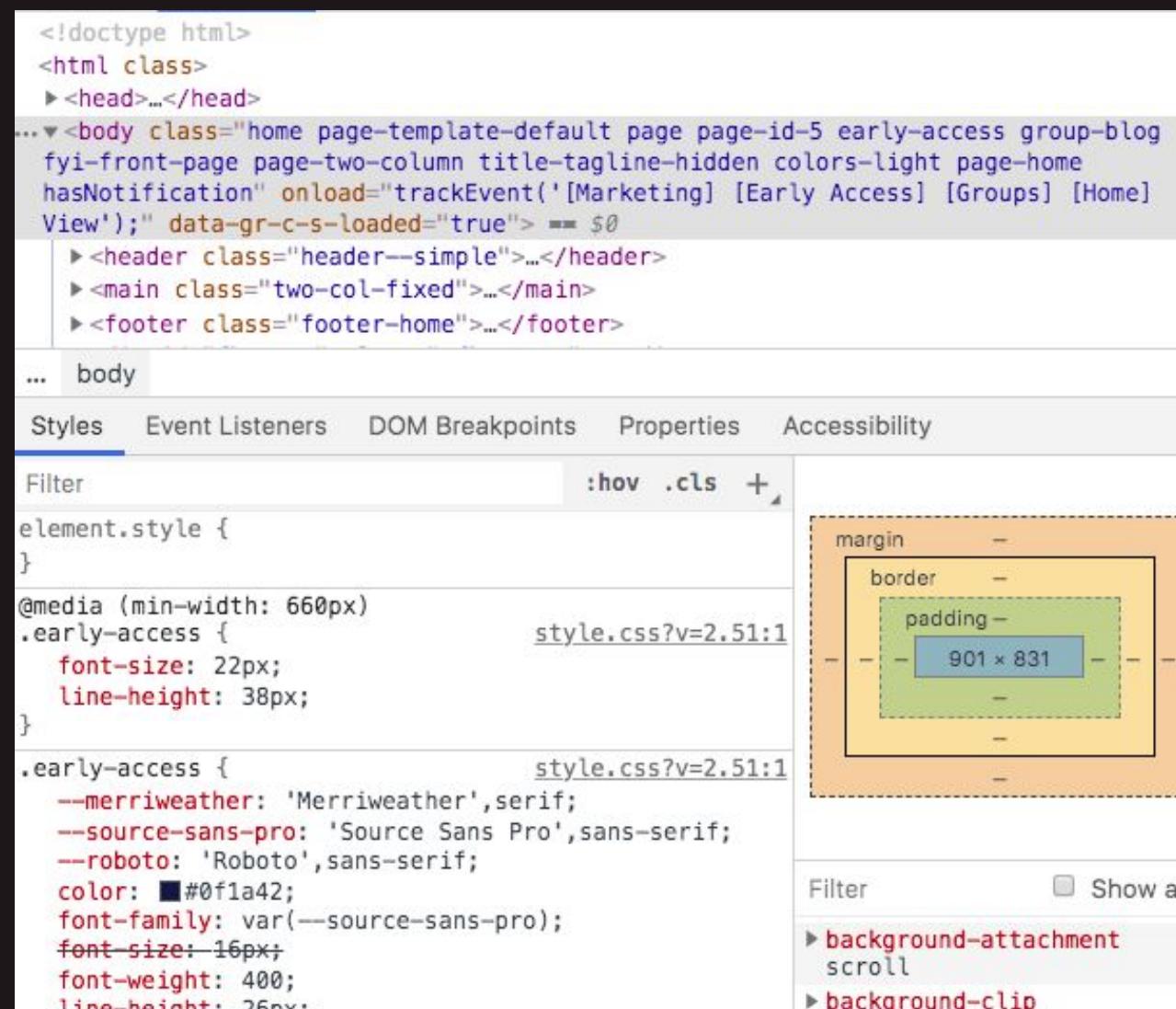
[8]



[9]

INTERFACE 1: USER INTERFACE

Components



A screenshot of the Chrome DevTools Elements tab. It shows the HTML structure of a page with various class and ID selectors. The right panel displays the computed styles for a specific element, including padding, border, and margin. A detailed breakdown of the element's dimensions is shown in a callout box.

```
<!doctype html>
<html class="...>
  <head>...</head>
  <body class="home page-template-default page page-id-5 early-access group-blog fyi-front-page page-two-column title-tagline-hidden colors-light page-home hasNotification" onload="trackEvent('Marketing [Early Access] [Groups] [Home View]'); data-gr-c-s-loaded=true" style="margin: 0; padding: 0; font-family: Merriweather, serif; font-size: 16px; line-height: 1.5; color: #0f1a42;">...>
    <header class="header--simple">...</header>
    <main class="two-col-fixed">...</main>
    <footer class="footer-home">...</footer>
  </body>
```

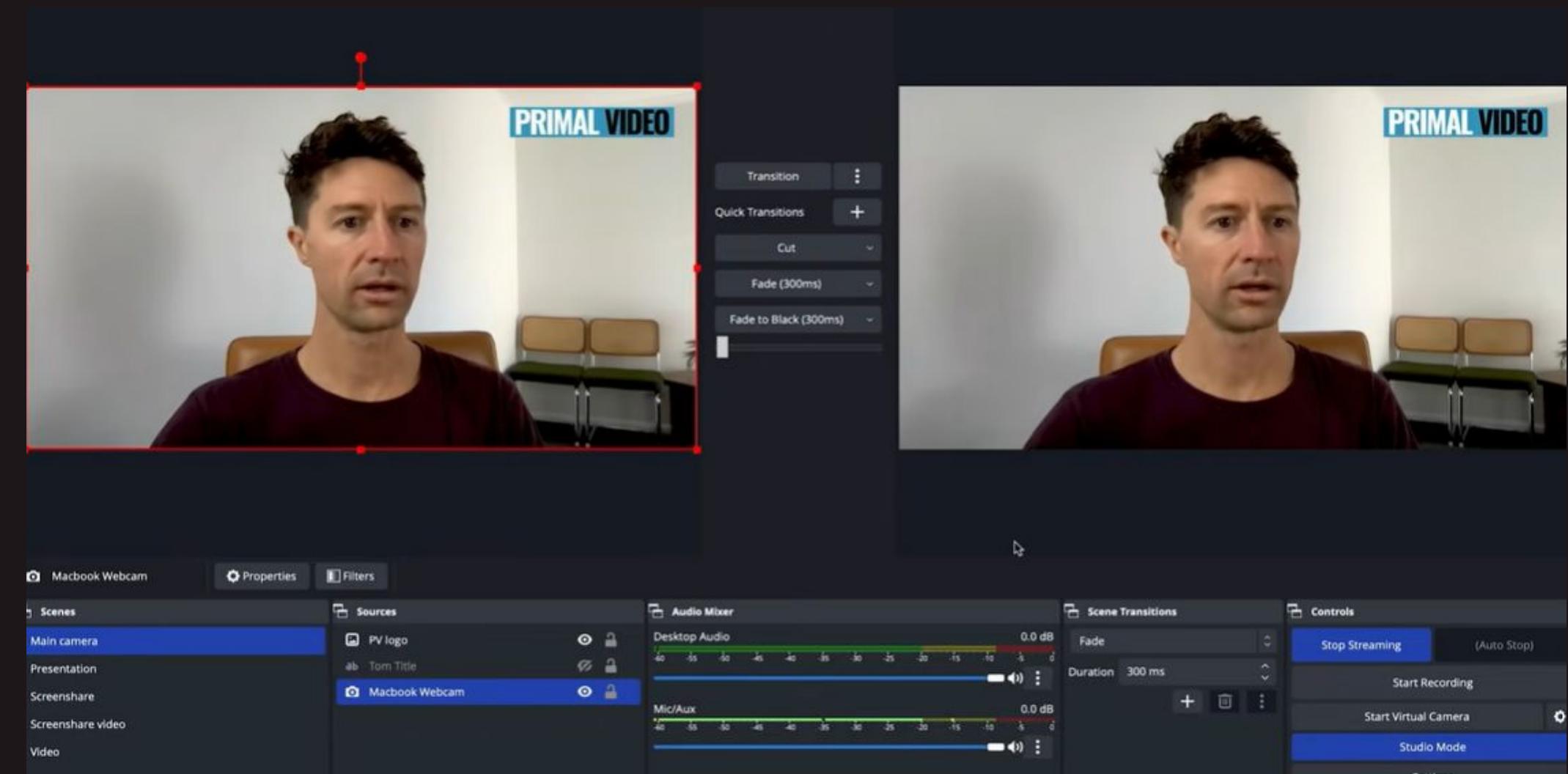
Styles Event Listeners DOM Breakpoints Properties Accessibility

Filter :hov .cls +

element.style {

```
@media (min-width: 660px)
.early-access {
  font-size: 22px;
  line-height: 38px;
}

.early-access {
  --merriweather: 'Merriweather', serif;
  --source-sans-pro: 'Source Sans Pro', sans-serif;
  --roboto: 'Roboto', sans-serif;
  color: #0f1a42;
  font-family: var(--source-sans-pro);
  font-size: 16px;
  font-weight: 400;
  line-height: 26px;
}
```



Frontend Programmed Using HTML
(using Chrome DevTools) [10]

Video Stream Programmed in
C/C++/Python (using OBS Studio) [11]

INTERFACE 1: USER INTERFACE

Implementation

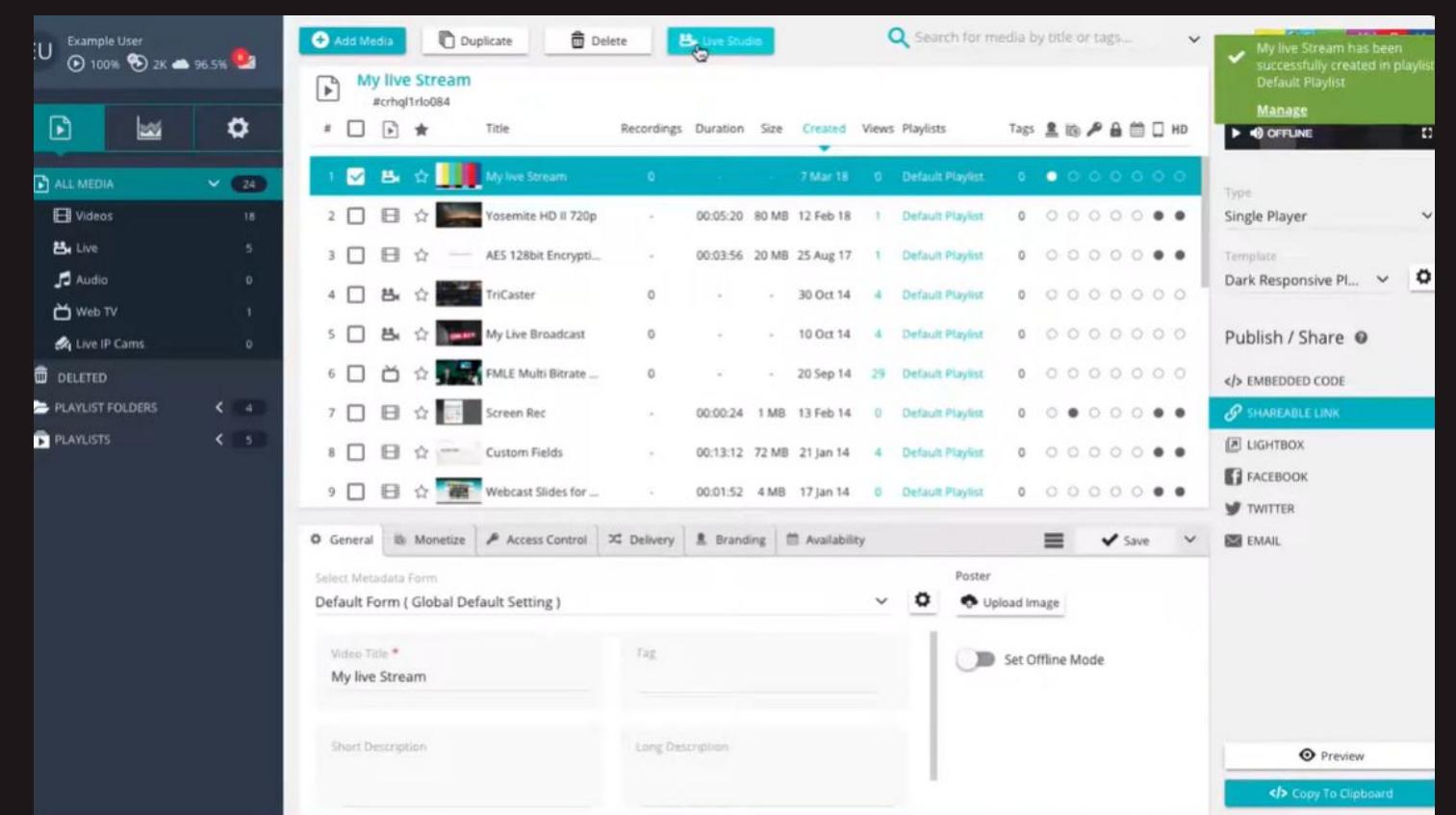
Integrating OBS Studio with the HTML platform

We will either:

1. Create an HTML overlay in OBS Studio
2. Turn OBS Studio feed into an embedded video on the HTML platform (using Real-Time Messaging Protocol or RTMP)



[12]

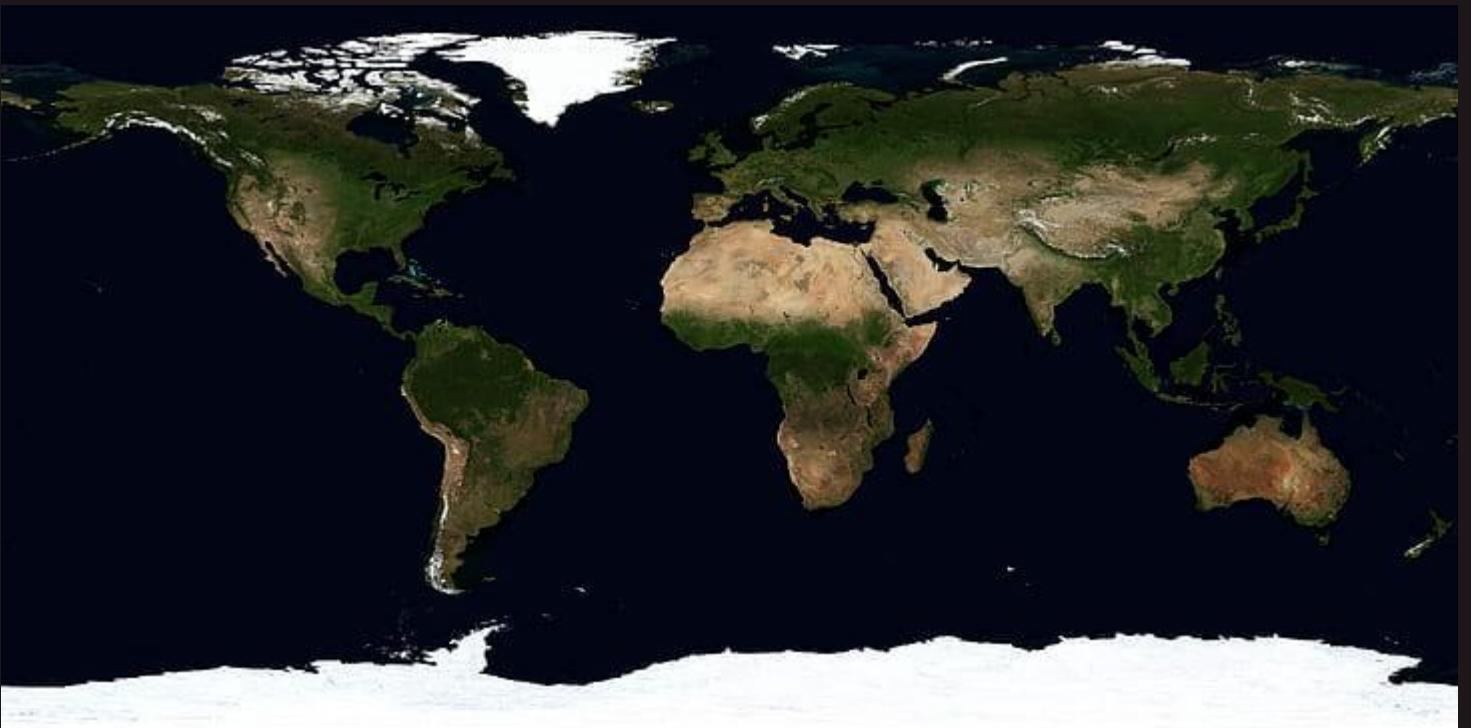


[13]

INTERFACE 2: CONNECTING INTERFACE

**Purpose & Goals: Long Distance
Connection**

- Develop a method to connect any device at any location to the remote lab at UMD
- Through Wi-Fi and web servers



[14]

INTERFACE 2: CONNECTING INTERFACE

Components



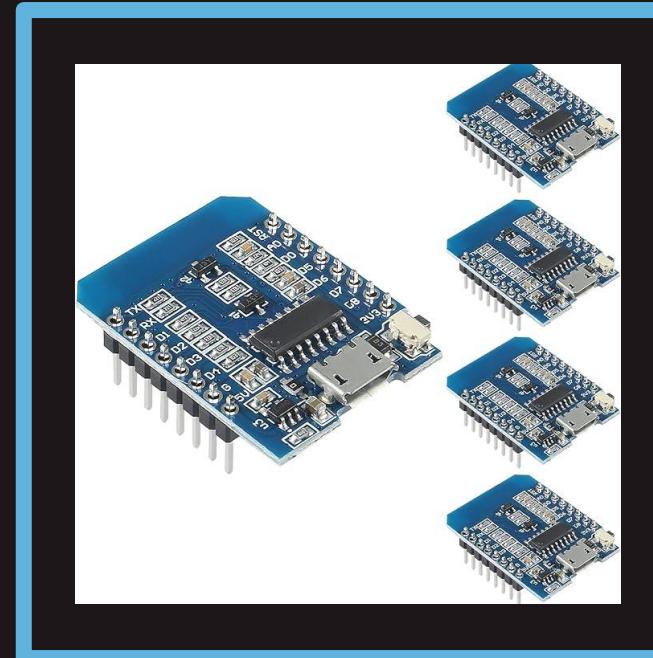
ARDUINO MEGA

[Amazon Link \[15\]](#)



ESP32

[Amazon Link \[16\]](#)



ESP8266 (alt.)

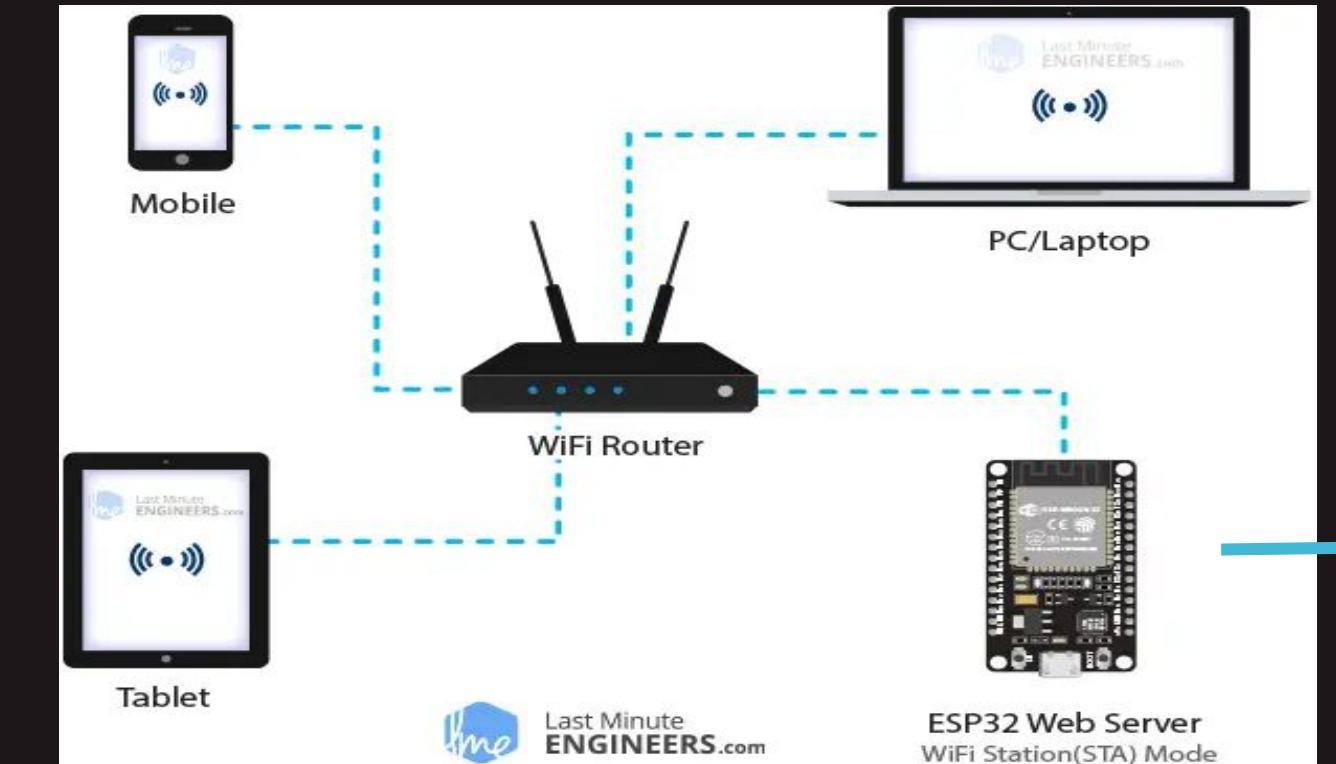
[Amazon Link \[17\]](#)



COMPUTER [18]

INTERFACE 2: CONNECTING INTERFACE

Implementation

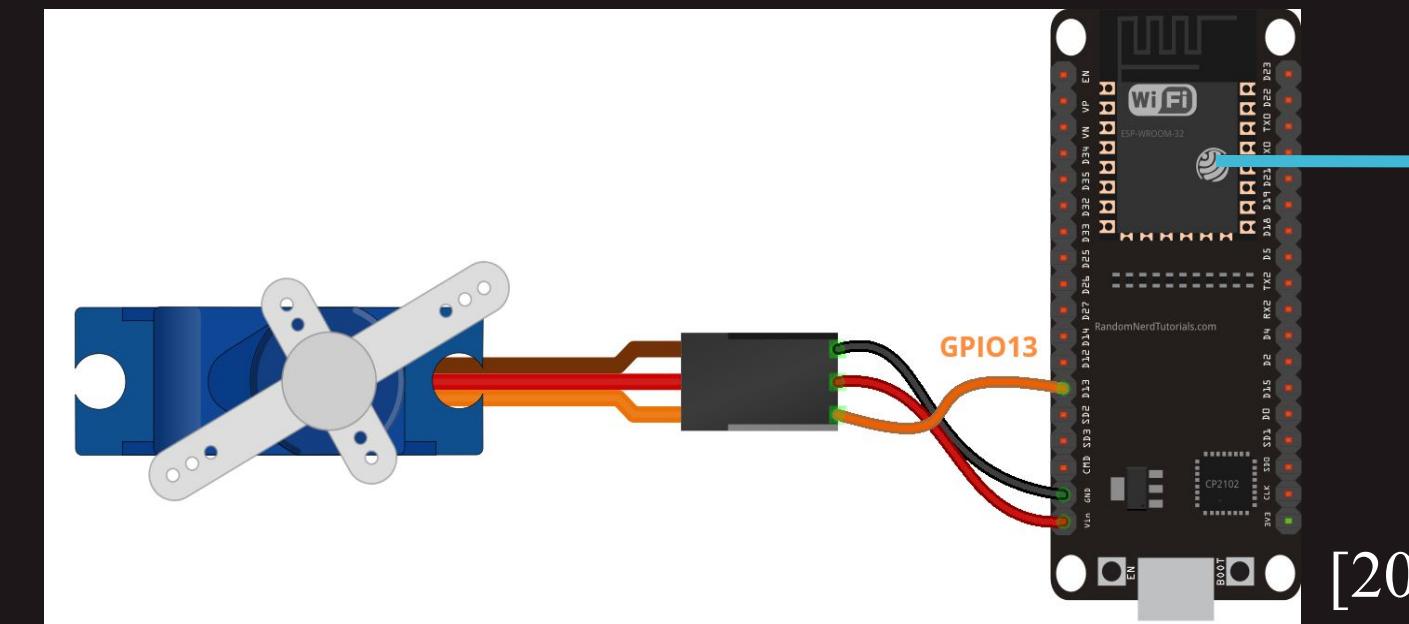


1. Setting Up the
Wifi Module in
Arduino IDE

2. Creating a
Functional Web
Server

3. Integrating GPIO
for Hardware
Control

4. Testing and
Refining the
System



INTERFACE 2: CONNECTING INTERFACE

Demo

Live interface for remotely controlling lab equipment.

Commands are sent via the web interface



2nd Interface Demo

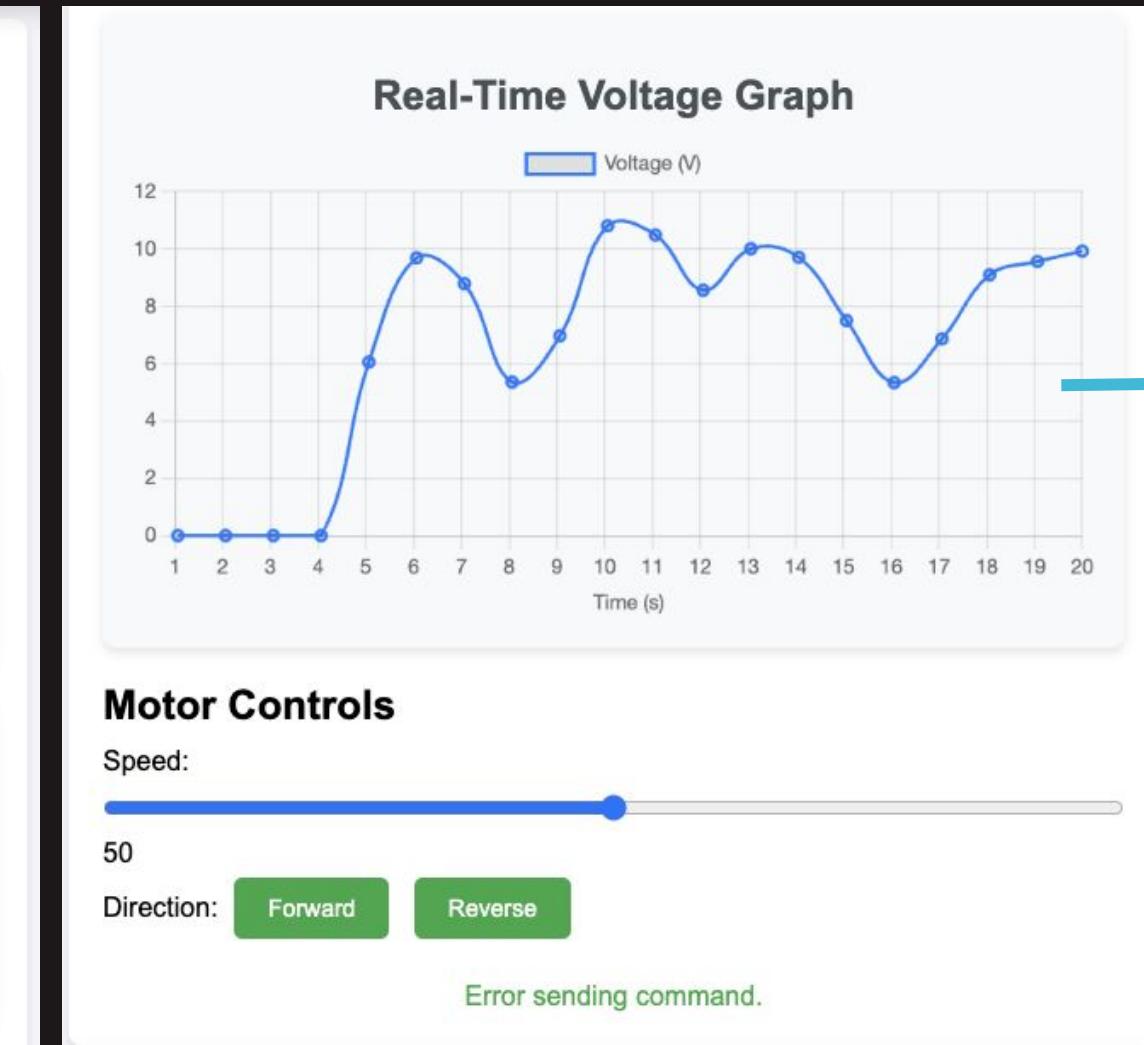
Control the lab equipment remotely using the interface below:

LED Status

Motor Status

Buttons: Turn LED On, Turn LED Off, Start Motor, Stop Motor

Instant feedback and live equipment monitoring



Real-time data visualization for lab experiments



INTERFACE 3: LAB INTERFACE

[21]

Purpose & Goals: The Physical Lab

- Develop a method to actuate/execute the user's commands within the physical lab
- Accurately relay experimental results

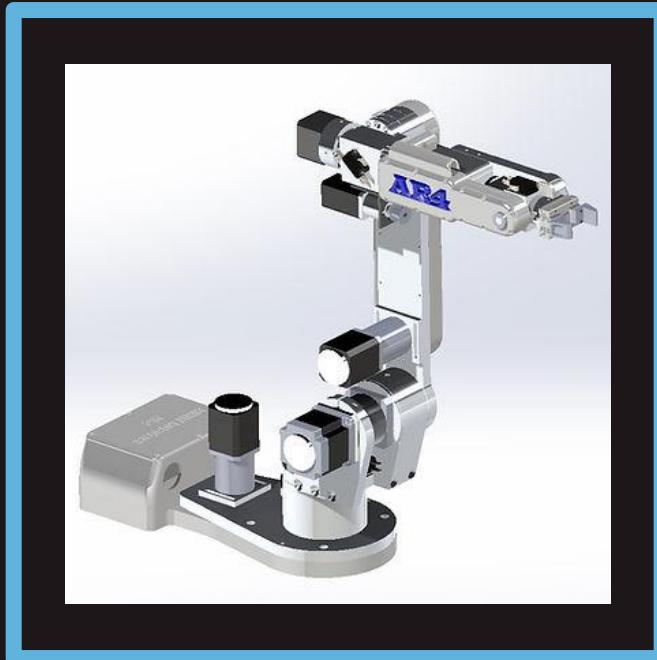


INTERFACE 3: LAB INTERFACE

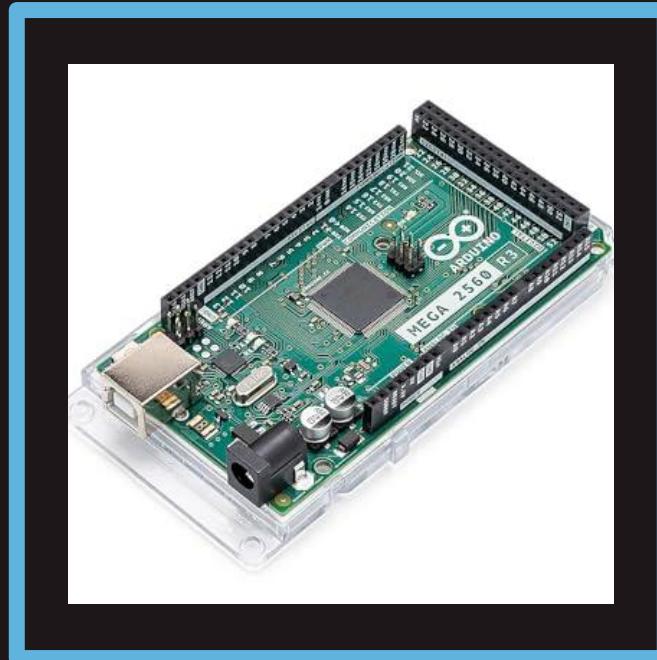
Components



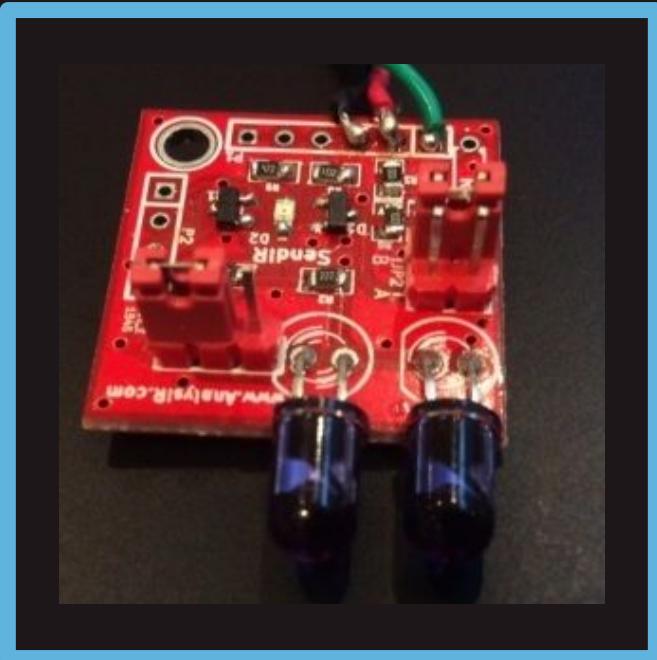
CAMERA(S) [22]



ANNIN ROBOTIC
ARM [23]



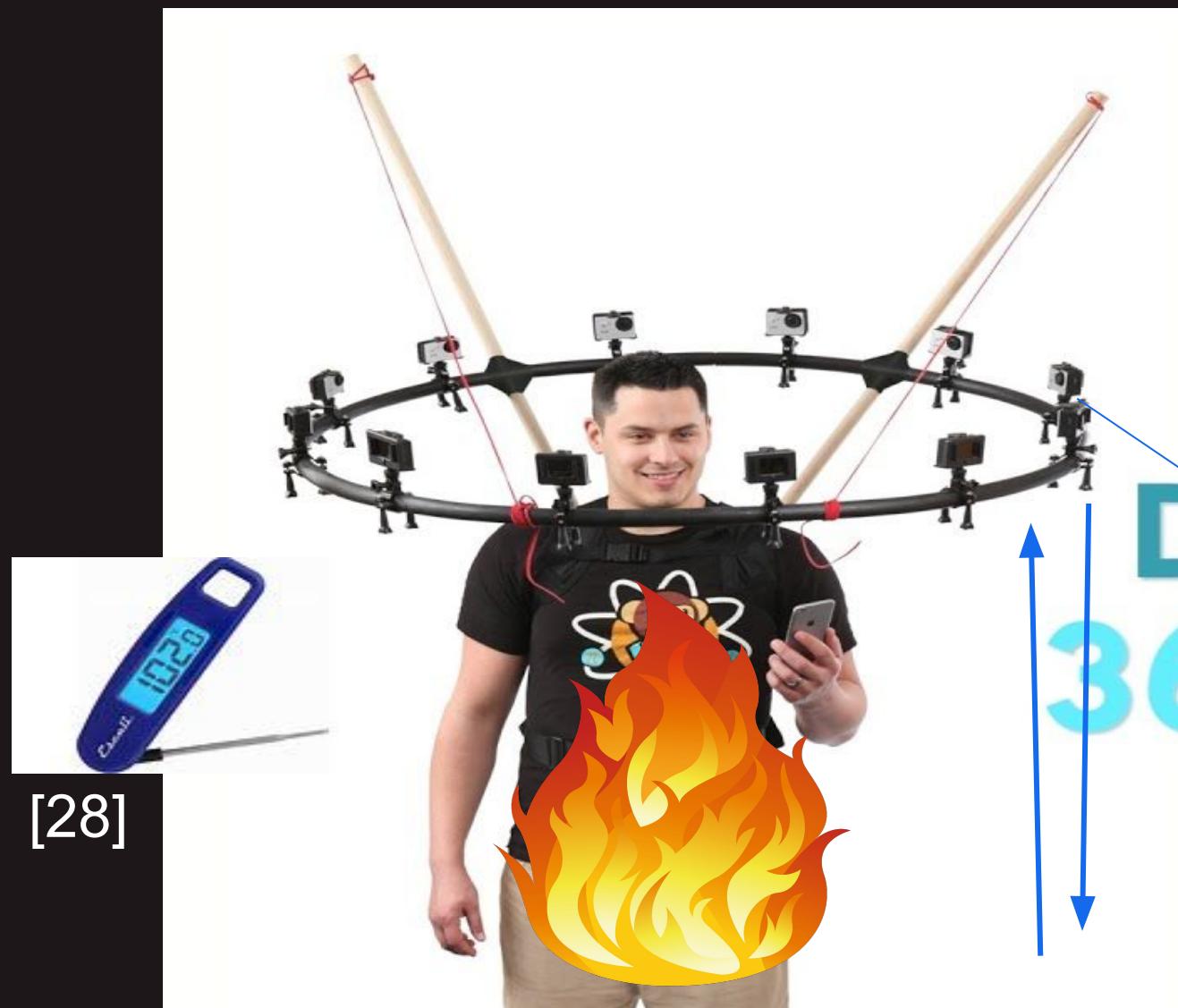
ARDUINO MEGA
[15]



IR Emitter [24]

- Components are dependent on and vary with the type of lab being used

INTERFACE 3: POTENTIAL LABS



[25]

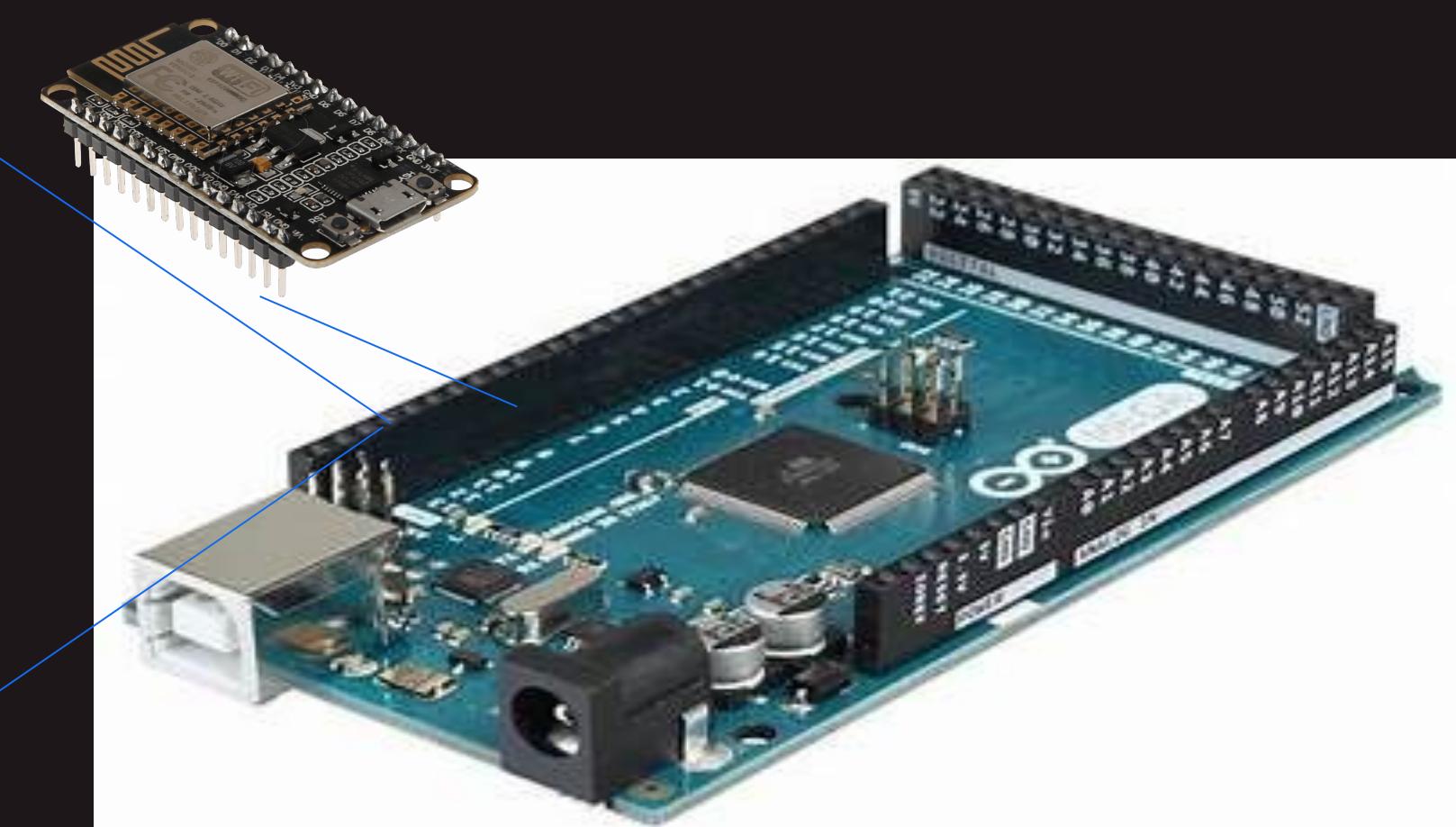


[26]



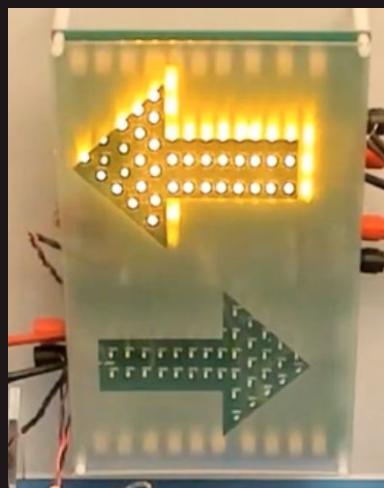
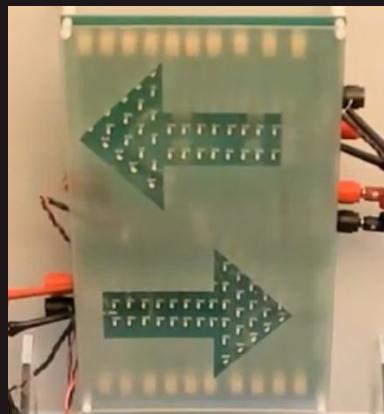
Fire Protection Engineering LAB

Locating the hottest part of a flame
Fire tornado with adjustable parameters

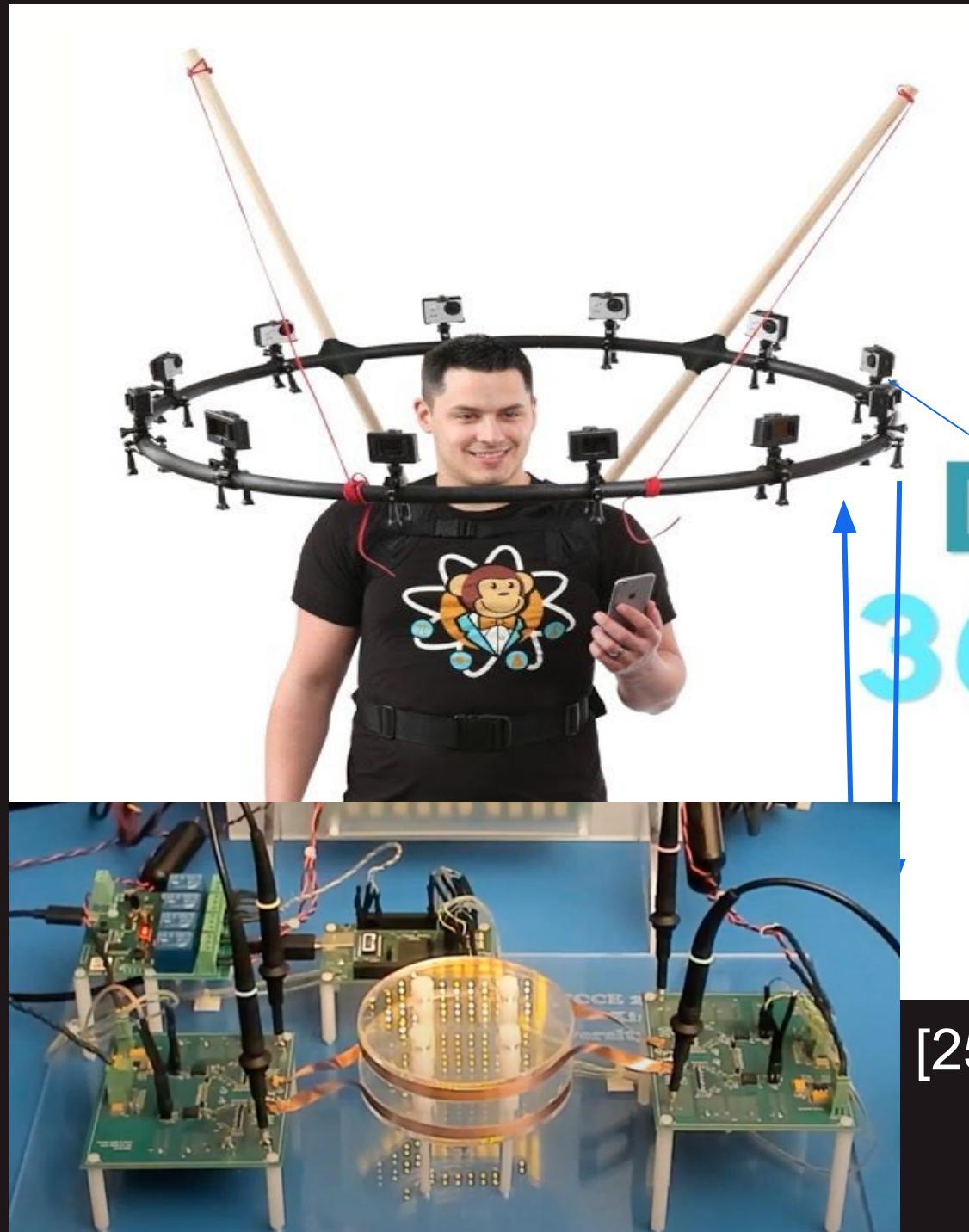


[15]

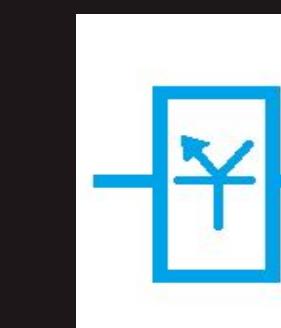
INTERFACE 3: POTENTIAL LABS



[30]

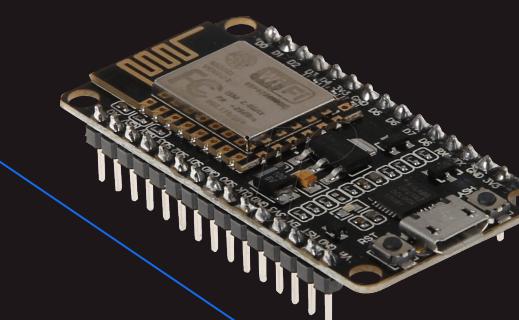


[25]



ELECTRICAL LAB

Variable current experiment

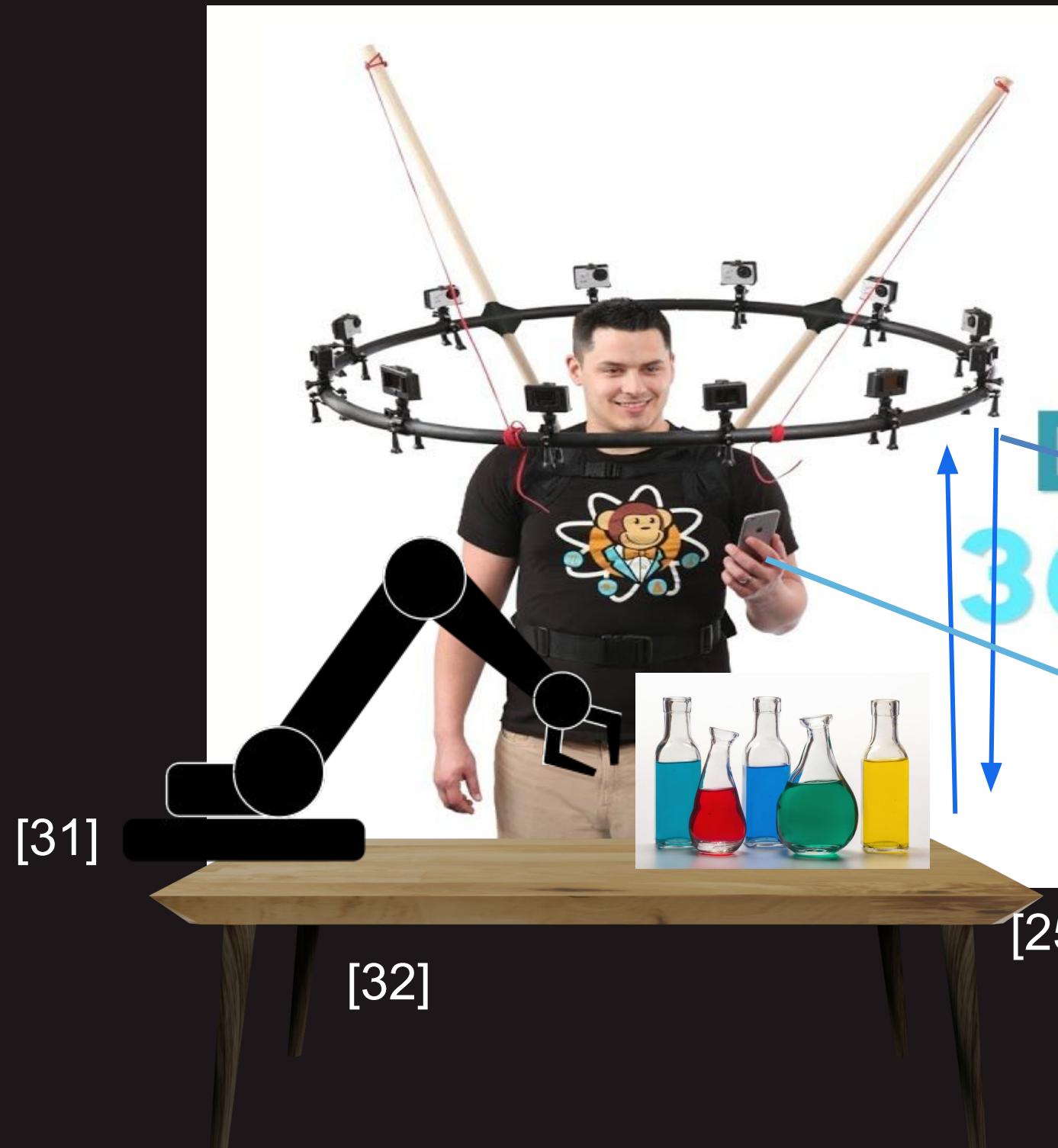


“alexa turn on light”



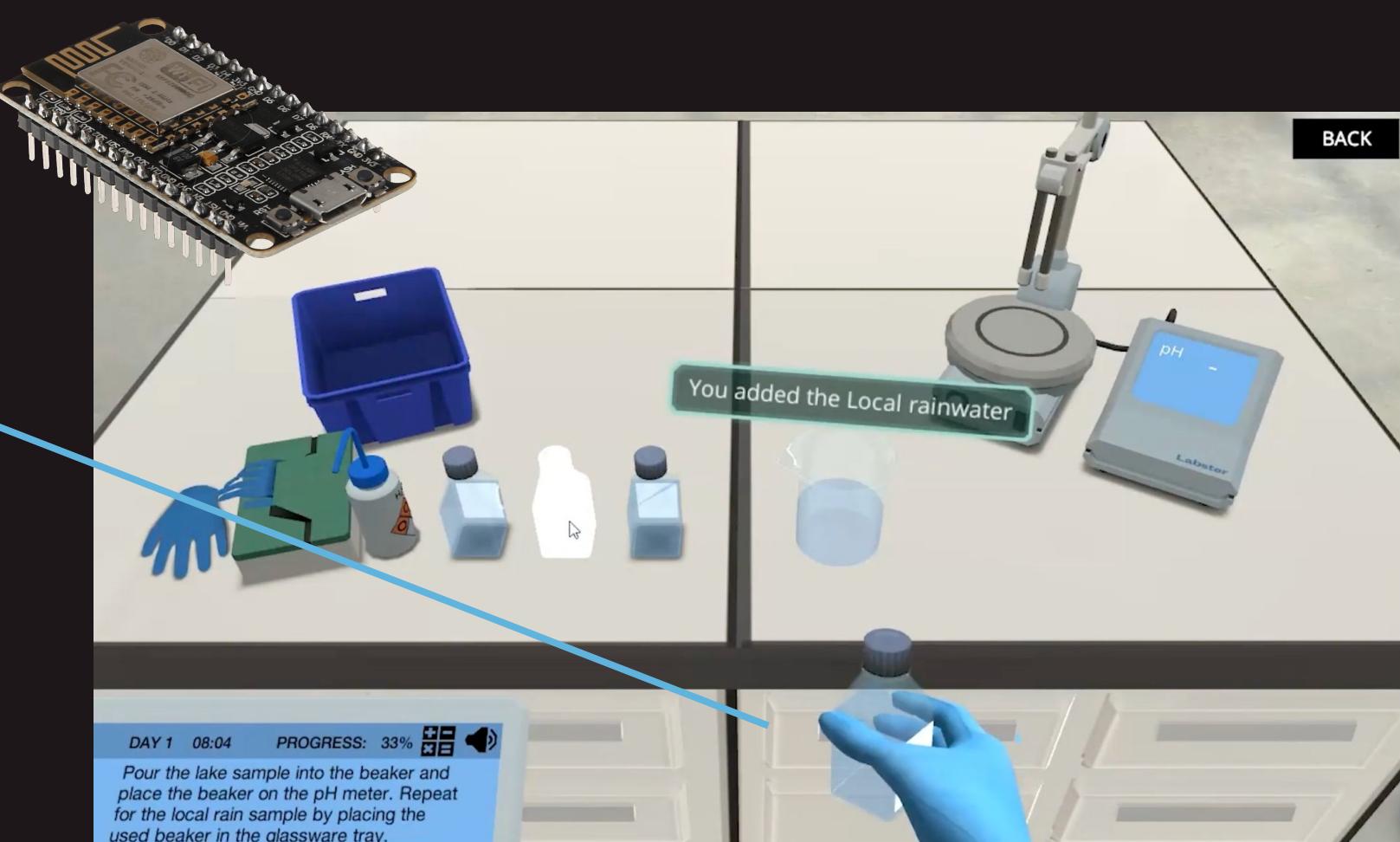
[29]

INTERFACE 3: POTENTIAL LABS



ALTERNATIVE

If neither of first two work, backup includes chemistry and physics labs



REQUIREMENTS FOR SUCCESS



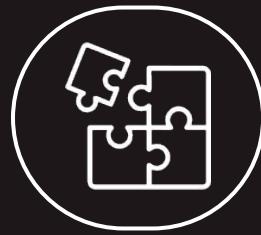
1. Meaningful Interaction

Functional Prototype



2. Educational Impact

Engagement and Learning Outcomes



3. Accommodations for Disabilities

Accessibility for Disabled Students



4. Cost

Minimizing cost to access and use



EQUITY & IMPACT

Stakeholders:

- Students
- Educators

Potential Concerns:

- Inaccessible to students with physical disabilities such as Down syndrome and neurological disabilities such as dyslexia
- Cost of remote lab creating a barrier for students in lower income environments



FEASIBILITY



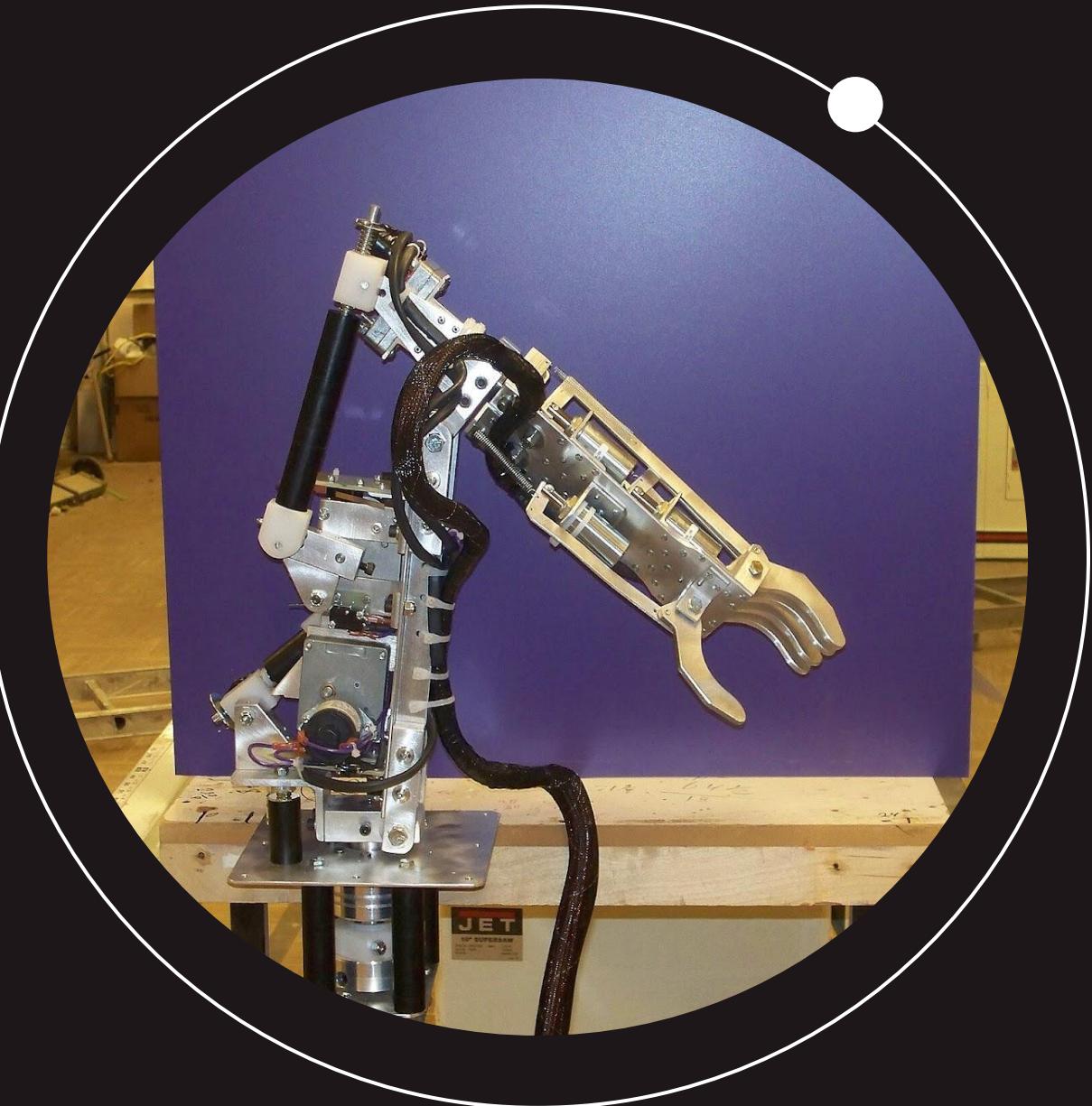
- Cost less than physical alternative
- Connections with Experts
- Storage



[35]

KEY TAKEAWAYS

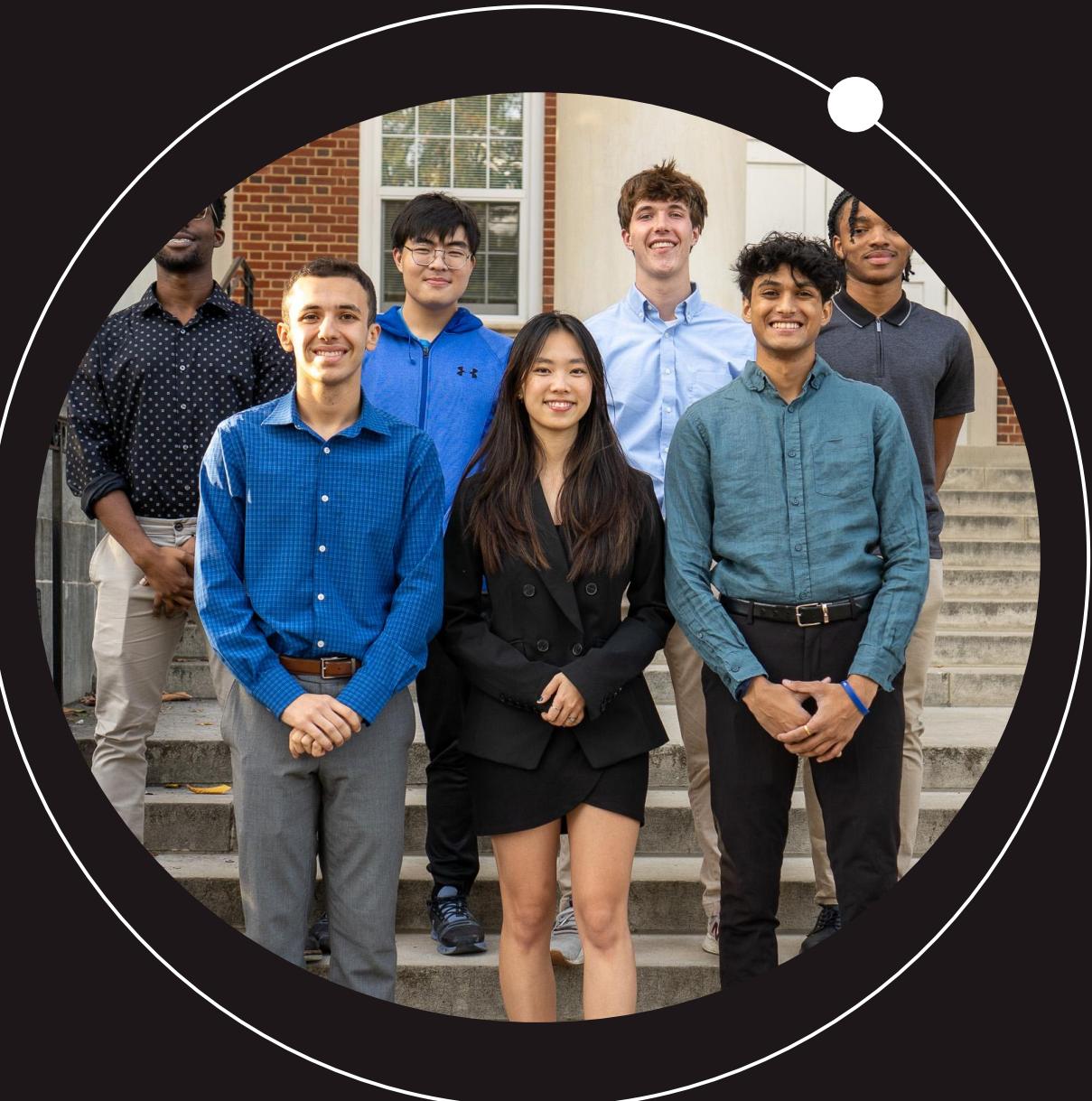
- Working to build remote labs currently only available in person
- Our proof of concept can be used for a variety of other labs



[1]

NEXT STEPS: SPRING 2025

- Finalize Proposal
- Submit IRB
- Formalize Partnership with FPE
- Build Proof of Concept
- Begin Initial Design



TIMELINE: FUTURE STEPS

- F25 • Finish Prototype v1
• Do Good Showcase
• Begin Student Testing

- S26 • Finish Data Collection
• Revise Design
• Evaluate Broader Implementation
• Begin Thesis

- F26 • Complete Data Analysis
• Finish Draft Thesis
• Prepare for Thesis Conference

S27 Finish, Present, and Defend our Thesis

ACKNOWLEDGEMENTS



Dr. Xin Zan
Team Mentor



Sarah Clinton-McCausland
Team Librarian

GEMS Director
Dr. David Lovell

GEMS Associate Director
Dr. Allison Lansverk

Operations Specialist
Leslie Lizama

Program Manager for Student Engagement
Brianna Lucas

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