Mushroom Nursery

An autonomous environment for enhanced primordia formation and fruit body development of mushroom cultures.

University of Central Florida
Department of Electrical Engineering and Computer Science

Group #5
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Motivation

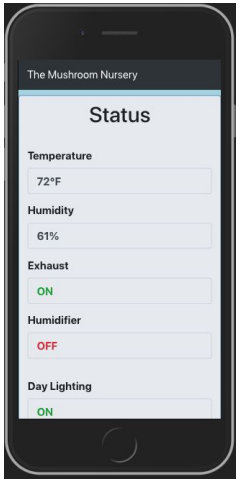
- We enjoy Mushrooms because they’re delicious and healthy.
- But sadly most grocery store don’t offer gourmet varieties.
- This is because gourmet mushrooms are hard to grow in bulk and have a short shelf life.

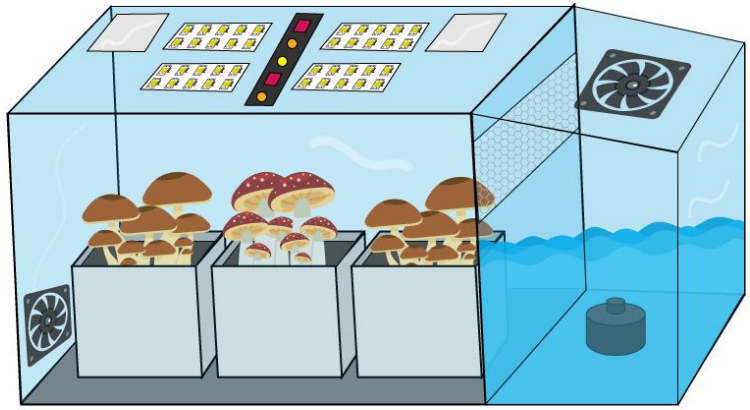
Project Goals

- Let users easily grow their favorite mushrooms at home.
- Build a self maintaining mushroom nursery.
- Give consumers access to a large variety of fresh mushrooms.

Overview

- Table top nursery that monitors and controls the grow environment for ideal conditions.
- WiFi connected controller that sends sensor data to a web server.
- Web App that allows for remote monitoring & management.





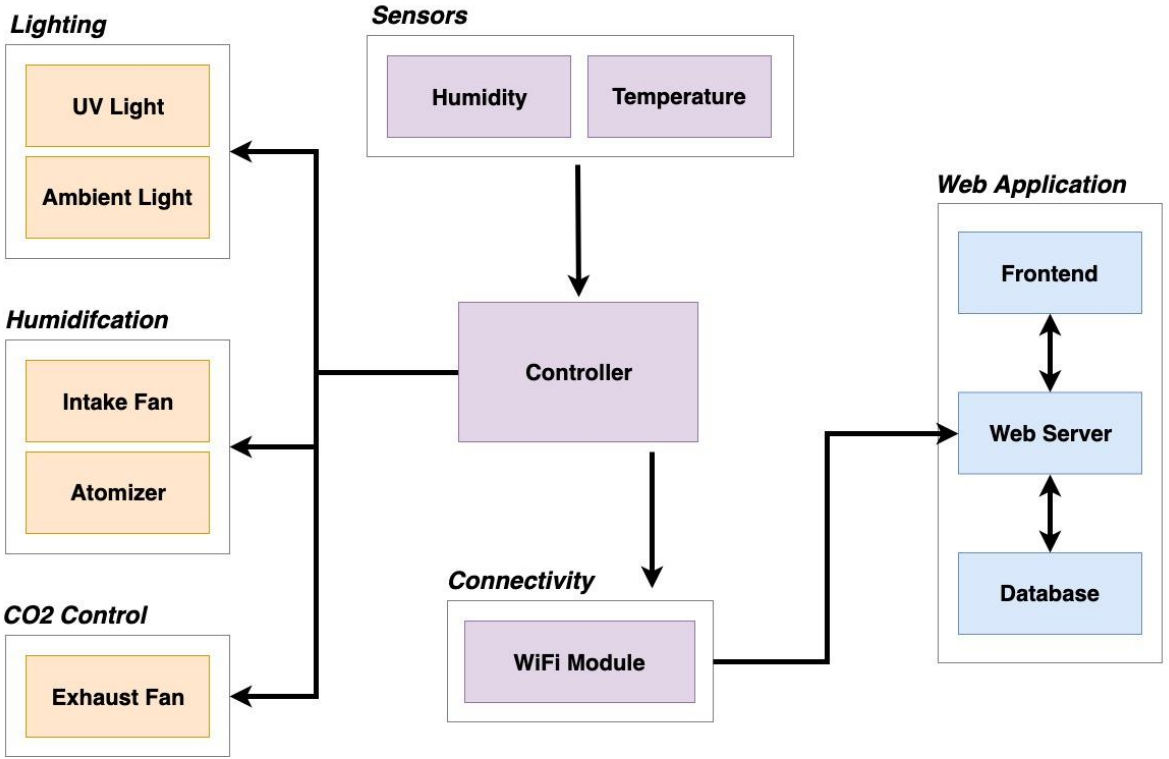
Project Design

- Used House of Quality process to find most important features.
- Circuits prototyped with a breadboard.
- Controllers evaluated with Development Boards.
- PCB designed using Easy EDA, and assembled by PCBWay.
- Software and Hardware unit tested.

Core Specifications

1	User can manually enable humidifier, fans, and lights on the web app, and the nursery will update within 60 seconds.
2	Ability to get updated temperature and humidity readings on the web app at least every 60 seconds.
3	Ability to raise internal relative humidity from room level to 80% within 10 Minutes.
4	Ability to achieve internal relative humidity of at least 90%.
5	Nursery can automatically maintain 85-90% humidity, and exhaust CO2 every minute.
6	User receives an alert within 5 minutes of the humidity falling below 70%.

System Overview



Primary Assignment:


Mardochee


David

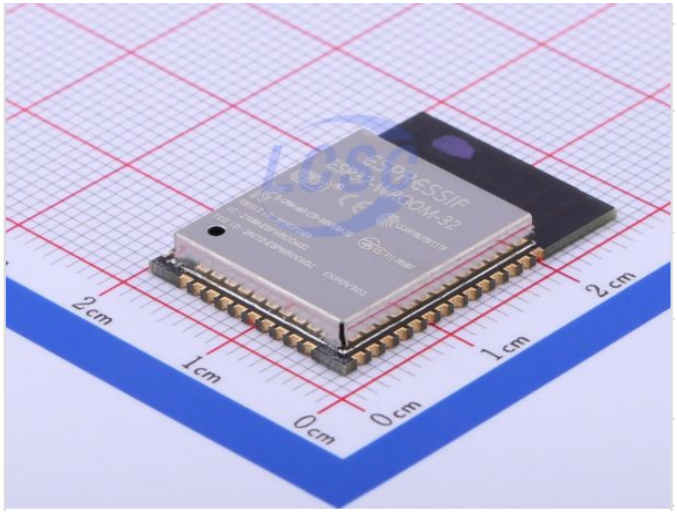

John

Controller

Component	Cost	Size (mm)	Internal Flash	Internal WiFi	GPIOs
Microchip SAMD21	$3.53	7 x 7 x 0.5	256 KB	No	38
Microchip ATSAMW25	$12.05	15 x 34 x 2	256 KB	2.4 GHz	15
Espressif ESP32 WROOM	$3.80	18 x 25 x 3	4 MB	2.4 GHz	21

Controller

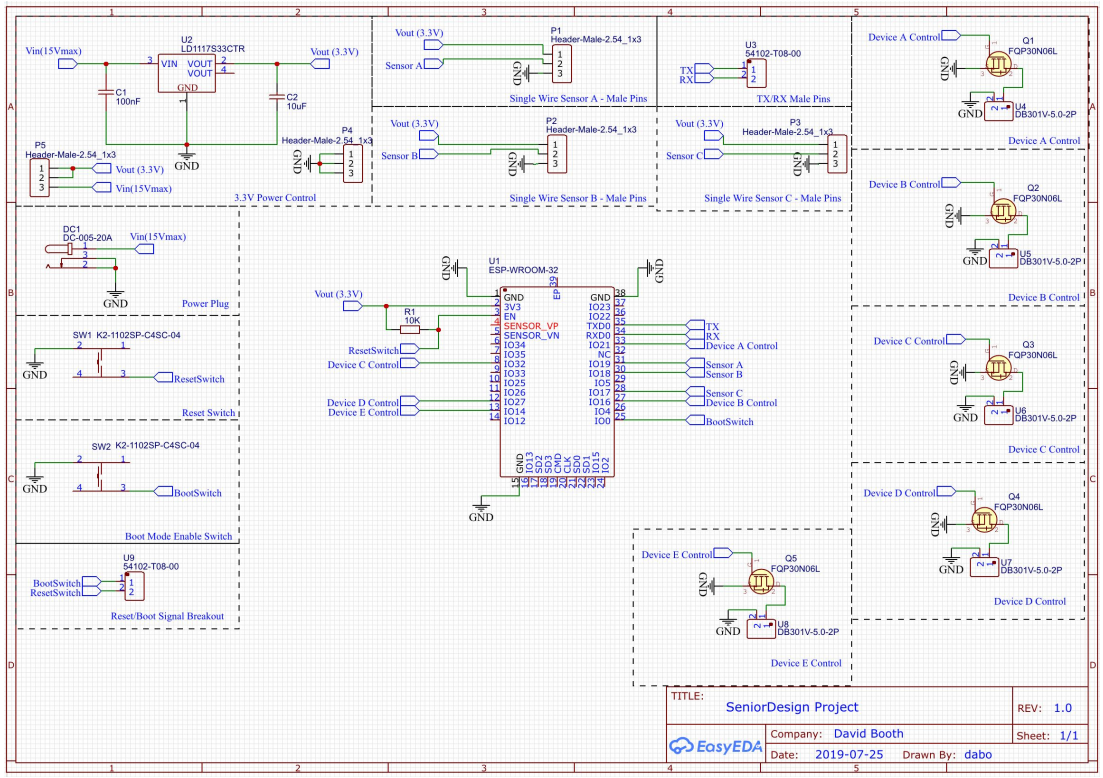
- WROOM-32D packaging.
- Protective metal casing with antenna for the WiFi module.
- 32 bit dual core processor.



ESP32

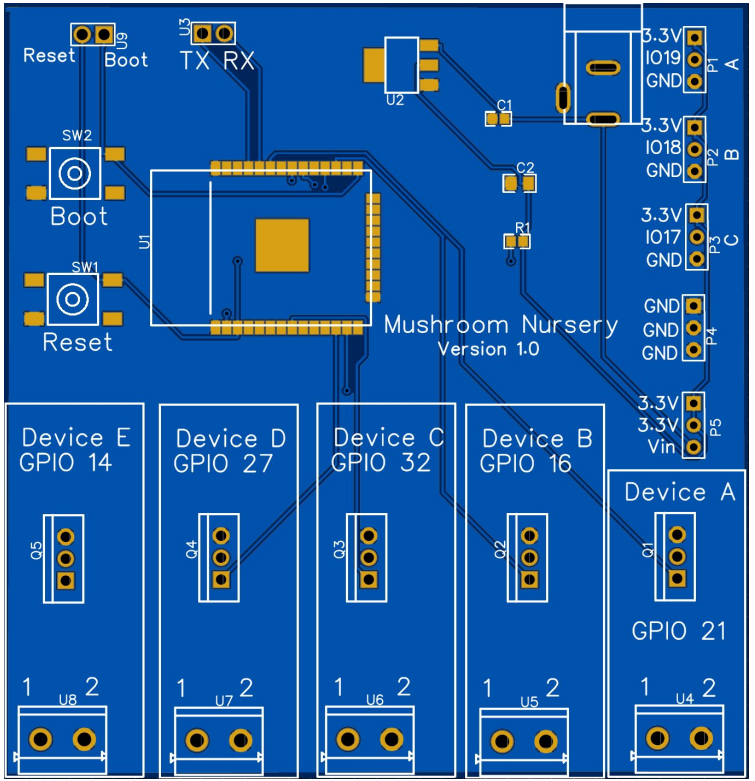
Internal Flash Memory	4MB and 16 MB available
Wireless Connectivity	2.4 GHz WiFi supporting 802.11 b/g/n Bluetooth 4.2 including Bluetooth LE
Number of GPIOs	21 including DACs and ADCs
Wired Protocols	UART, SPI, I2C, I2S
Operating Voltage	3.3 V

Schematic


U2
LD1117S33CTR
Vin(15Vmax)
Vout (3.3V)
C1
100nF
C2
10uF
P5
Header-Male-2.54_1x3
P4
Header-Male-2.54_1x3
3.3V Power Control
P1
Header-Male-2.54_1x3
Sensor A
Single Wire Sensor A - Male Pins
P2
Header-Male-2.54_1x3
Sensor B
Single Wire Sensor B - Male Pins
P3
Header-Male-2.54_1x3
Sensor C
Single Wire Sensor C - Male Pins
U3
54102-T08-00
TX
RX
TX/RX Male Pins
Device A Control
Q1
FQP30N06L
U4
DB301V-5.0-2P
Device B Control
Q2
FQP30N06L
U5
DB301V-5.0-2P
Device C Control
Q3
FQP30N06L
U6
DB301V-5.0-2P
Device D Control
Q4
FQP30N06L
U7
DB301V-5.0-2P
Device E Control
Q5
FQP30N06L
U8
DB301V-5.0-2P
DC1
DC-005-20A
Power Plug
SW1 K2-1102SP-C4SC-04
ResetSwitch
Reset Switch
SW2 K2-1102SP-C4SC-04
BootSwitch
Boot Mode Enable Switch
U9
54102-T08-00
Reset/Boot Signal Breakout
U1
ESP-WROOM-32
R1
10K
SENSOR_VP
SENSOR_VN
Device A Control
Sensor A
Sensor B
Sensor C
Device B Control
BootSwitch
TITLE:
SeniorDesign Project
REV: 1.0
EasyEDA
Company: David Booth
Sheet: 1/1
Date: 2019-07-25
Drawn By: dabo

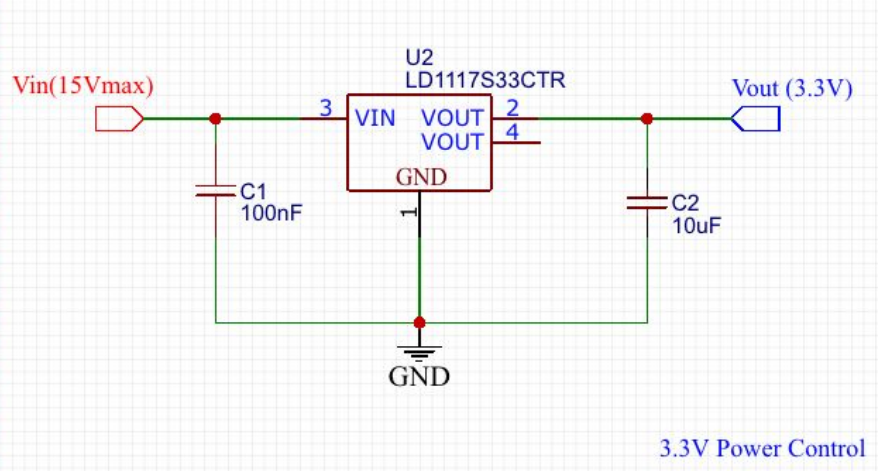
PCB Design

- 2 Layer PCB
- Wider Traces on MOSFET connections
  - Better thermostability
- Troubleshooting breakouts.
- UART breakouts.
- Boot and Reset buttons.



Board & Sensor Power Solution

- AC-DC Wall adapter connected via barrel jack.
- Regulating up to 15V input down to 3.3V.
- Controller and Sensors run on 3.3 V.



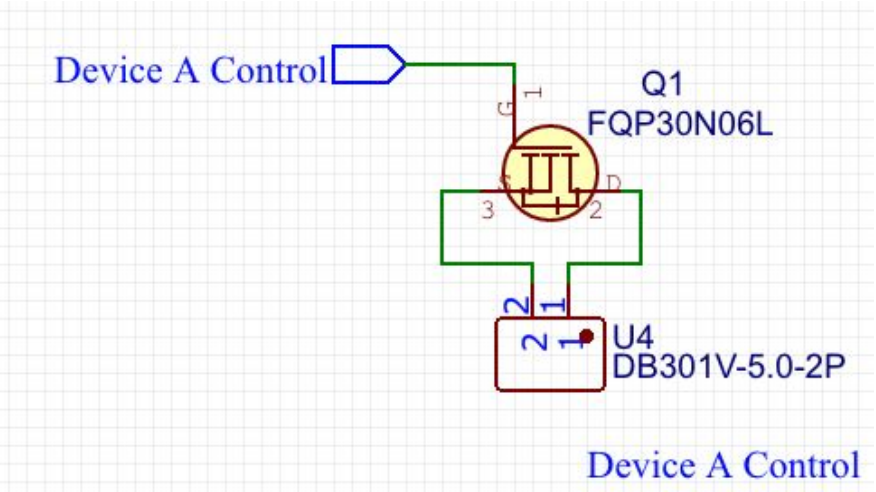
Power Regulator

Component	Cost	Size (mm)	Max. Input (V)	Max. Current (mA)	Accuracy	Max. Temp
Diodes Inc. AP2112K	$0.47	3 x 1.6 x 1	6	600	1.5 %	85 C
STMicroelectronics LD1117	$0.46	2.5 x 6.6 x 6	15	800	2 %	125 C
Texas Instruments TPS709	$1.12	1.4 x 3 x 1	30	150	2 %	125 C

LD1117 Operating Temperature estimated at 49 C.

Devices

- Devices are powered with AC-DC Wall Adapters.
- They are connected via screw terminals.
- Controlled via MOSFETs.



MOSFETs

Component	Cost	Size (mm)	Max. Voltage (V)	Max. Current (A)	Max. Temp (C)
Fairchild FQP30N06L	$0.95	10x14x4.5	60	32	175
ON Semiconductor FDMS3660S	$1.20	6x5x1.1	30	30	150
STMicroelectronics STD4N52K3	$1.14	10x6.5x2	525	3.8	150

MOSFET Temperature

	Max. D-S Voltage	Max. Current	Max. Temperature
FQP30N06L	60 V	32 A @25C 22 A @100C	175 C
	Operating Voltage	**Max. Current**	**Junction Temp.**
Light	12 V DC	1.2 A	28 C
Fan	5 V DC	280 mA	25 C
Humidifier	24 V DC	700 mA	26 C

Humidification Solution

- Mushrooms require high levels of humidity (80-100% RH).
  - Exact levels depends on Mushroom variety.

- The user is able to set the desired humidity level via the web app.
  - Or select pre-configured mushroom profile.

- Controller reads humidity inside nursery, using humidity sensor.

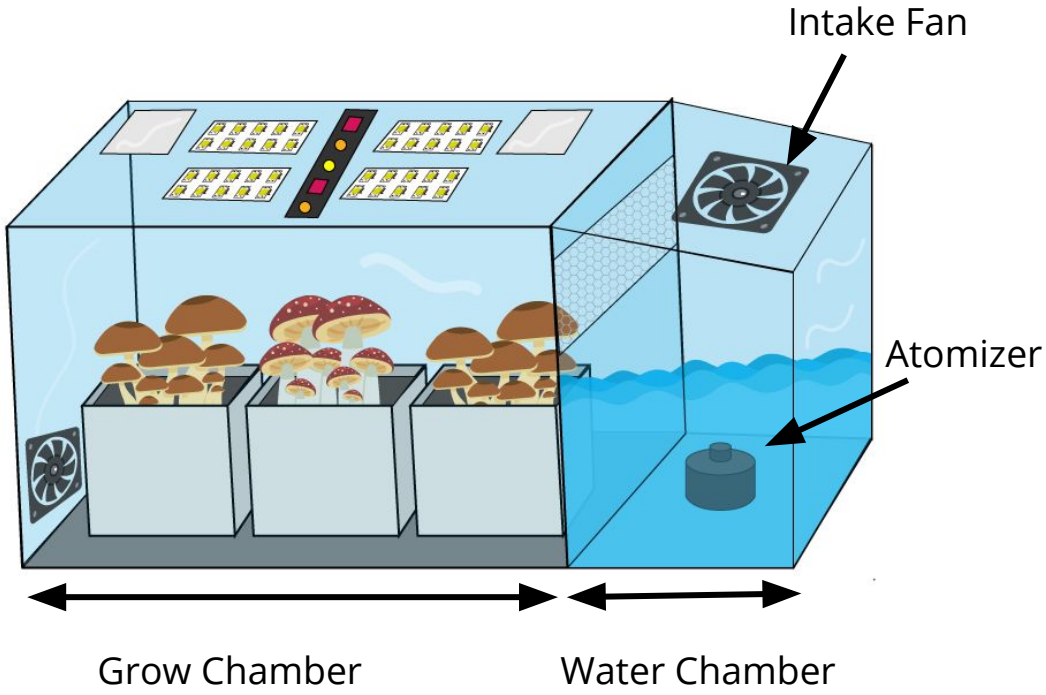
Humidification Methods

Option	Effectiveness	Method	Implementation Cost
Evaporative	Low	Wick + Fan	Low
Vaporization	High	Boiling	High
Ultrasonic	High	Atomizer + Fan	Low

- Ultrasonic atomizer is placed within water chamber.
- Fan blows the humidified air into the growing chamber.

Humidification Solution

- Internal humidity level is monitored and humidifier engaged as needed.
- Water chamber needs to be refilled periodically.



Atomizer

AGPTek Ultrasonic Disc Atomizer	
Voltage	24 V DC
Max Current	700 mA
Water consumption	200-400 ml / hour
Size	3.5 cm diameter 4 cm tall
Cost	$12.99

Daylight Solution

- Minor Lighting helps with color and flavor development.
- LED light mounted inside the nursery.
- Controller will automatically turn on and off lights inside the chamber.
- User can manually override these options via the web app.

IP65 LED strip	
Voltage	12 V DC
Max Current	1.2 A
Wavelength	450-500 nm
Cost	$12.99

Ultraviolet Lighting Solution

- Ultraviolet light boosts Vitamin D content in mushroom.
- LED light mounted inside the nursery.
- User can manually enable or disable via app.

IP65 LED strip	
Voltage	12 V DC
Max Current	1.2 A
Wavelength	380-400 nm
Cost	$12.99

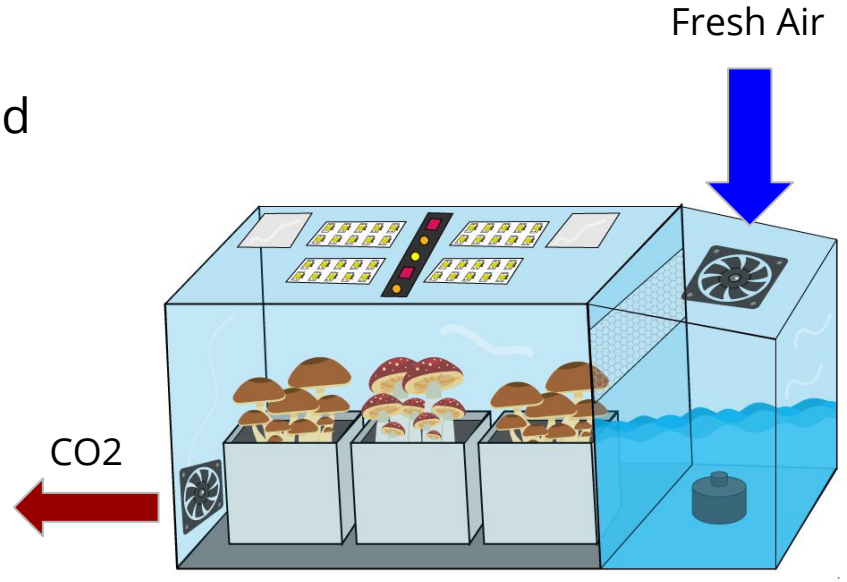
Housing Construction

- Assembled by hand.
- Water chamber lid design to recollect condensation.

	Cost	Durability	Bonding	Weight	Impact Resistance	Workability	Transmittance
Polycarbonate	$$$	Strong (200x)	Easy	Light	Great	Easy	88%
Acrylic	$$	Strong (8x)	Easy	Light	Great	Easy	92%
Glass	$	Easy to break	Difficult	Heavy	Poor	Hard	90%

Air Exchange Solution

- Mushrooms consume Oxygen and produce CO2.
- CO2 collects at bottom.
- CO2 must be pushed out with exhaust fan.
- Fresh Air is drawn in through opening in water chamber.

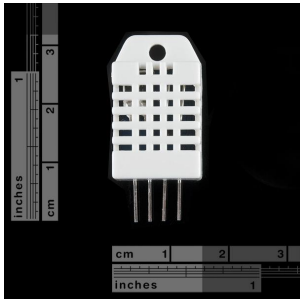


Air Exchange Component

- Controller schedules air exchanges periodically.
- User can define air exchange interval via web app.

Component	Cost	Size (mm)	Voltage (V)	Current (mA)	Noise (dBA)	Airflow (ft^3/min)
RDEXP 8025	$6.55	80x80x25	5	300	25	18
Cooler Master Blade Master 80	$18.32	80x80x25	12	200	28	40
GDSTIME B07MG	$10.99	80x80x10	5	280	27	20

Sensor Solution



Component	Cost	Size (mm)	V	Current	Readings	Connectivity
Honeywell HIH-5031	$27.27	9x4x3	2.7-5.5	200µA	Humidity	Analog Voltage
Texas Instruments TMP117	$5.27	8x6x1	1.8-5.5	3.5µA	Temperature	I2C
MaxDetect RHT03	$9.95	15x33x7.7	3.3	1.5mA	Temperature & Humidity	1-Wire Bus

Web Application Overview

- Our web app is mobile responsive and works on:
  - Computer
  - Tablet
  - Mobile device

- User can manually control the operation of the nursery.

- User can view sensor readings and mushroom profiles.

Web Application Solution

- React JS was chosen as the Web Framework.
- App interacts with the Web Server via a REST API.

	Angular	React	Vue
Size	566 KB	139 KB	58.8 KB
Large Community	Yes	Yes	No
Difficulty	Moderate	Easy	Easy
Setup time	Longer	Quick	Quick

Server & Database Solution

- Our server is based on Node.js, utilizing the express framework deployed on AWS via Heroku.
- Data is stored in a non-relational MongoDB database.
- Database is deployed on AWS via MongoDB Atlas.
- Server and Database are deployed in the same AWS region for reduced communication delay.

Successes

- In our testing environment we grew multiple oyster mushroom strains.
- In as short as 3 days, we grew large, great tasting mushrooms.
- Total we had over 2 pounds of mushrooms.
  - Ate most of them.
  - Dried some for later use.

Retrospective

- Learned from failed attempts.
- Humidity too low - deformed fruit bodies.
- CO_2 too high - longer stems.
- Because of those failed attempts we focused a lot on the humidification & air exchange system.

Work Distribution

	PCB & Controller	App & Server	Housing	Sensors & Devices
Mardochee	Tertiary		Secondary	Primary
David	Primary	Tertiary		Secondary
John	Secondary	Primary	Tertiary	

Stretch Goals

#	Goal
1	Active temperature control, utilizing Peltier devices for heating & cooling along with insulated housing.
2	Precompiled Mushroom Grow Profiles that define humidity level, air exchange intervals and light intervals.
3	CO2 Sensor integration to trigger air exchange on demand.
4	Ability to view Snapshots or Video of Nursery on App.
5	App can communicate to nursery via bluetooth as well as WiFi.

Current Project Spend

SparkFun ESP8266 Thing	$17.95
SparkFun Thing Plus - ESP32	$20.95
Break Away Headers	$1.50
ESP32 DEVKIT C Version 4	$14.95
PCB Components	$18.41
Fans	$15
Ultrasonic Atomizer	$6.99
Hosting	$22.00

Peltier Devices	$19.95
CO2 Sensor	$49.00
pH Sensor	$19.95
Humidity & Temp Sensor	$9.95
LED Lights	$25.98
Housing Materials & Tools	$160.50
Printing & Assembly of PCBs	$123.40
Total:	**$526.48**

Thank you.

Any Questions?

Please feel free to contact us for more information.

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Mardochee: mdccj101@knights.ucf.edu
David: david_booth@knights.ucf.edu