Monitoring Indoor Ventilation Efficacy using Outdoor Air Quality Sensor Stations

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Background

- The indoor air quality sensor aims to monitor and address the challenges presented by deteriorating air quality through implementation in living buildings.
- The sensor communicates indoor and outdoor air quality data to the cloud, working independently of Wi-Fi networks.
- Measures various air quality parameters including CO2 levels, percent humidity, temperature, and pressure.

IoT Sensor Mission

Primary Mission Goal:

- Transform the current indoor air quality sensor into a weatherproofed outdoor sensor, intended to collect data from the Kendeda building. These new sensors will provide data allowing us to better monitor the efficacy of indoor ventilation systems and improve them.

Secondary Goals:

- Ensure that the new outdoor model can be easily, affordably, and accurately produced and reproduced.

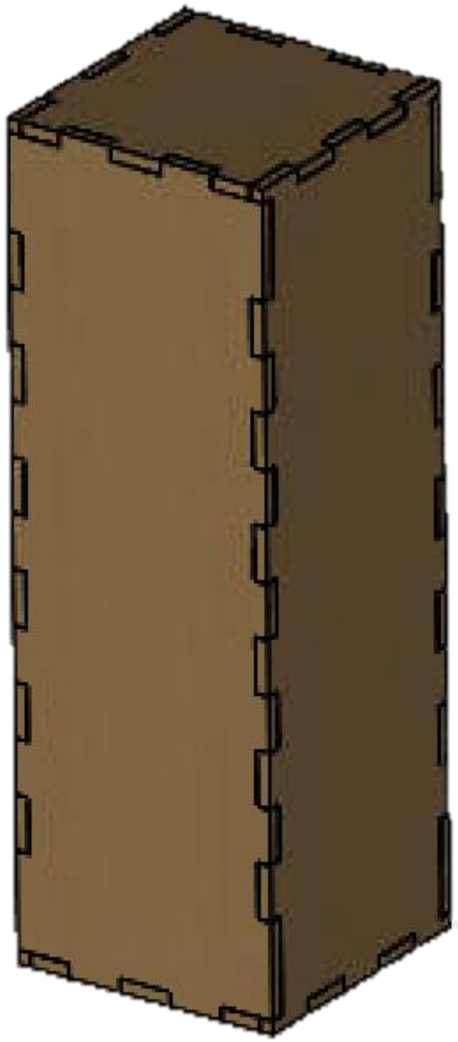
Design Decision:

- Use wood and laser cutting to create the outer sensor hardware and use 3D-printing to develop a weatherproofed wiring enclosure.

Timeline-First Generation Exterior

First Generation Outdoor Air Quality Sensor

- Laser cut a ⅛ inch wood box
- Weatherproof it using polyurethane (PU) and hot glue around the edges
- Transfer vent to the bottom of the device to add further proofing
- Use screen tape over the vent for added security
- Circuit board that will slot into the device
  - Circuit board will be attached to a laser cut piece of wood using zip-ties.



Iteration 1 Cons:

- Glue around the edges does not spread uniformly
- Shade would be required over the top of the sensor in order to provide accurate temperature readings

Timeline- Second Generation Exterior

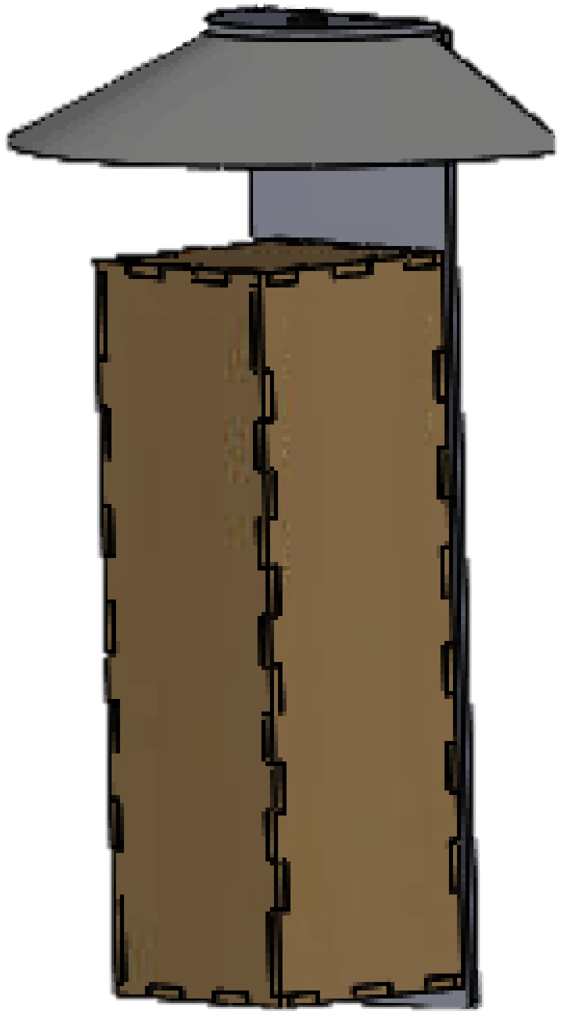
Second Generation Outdoor Air Quality Sensor

- 3D printed Umbrella station
- Connected to the sensor using heavy-duty Velcro
- Edges of the sensor are now secured by weatherproof insulation foam

Iteration 2: Cons

- Vent holes will be required to mitigate internal temperature issues

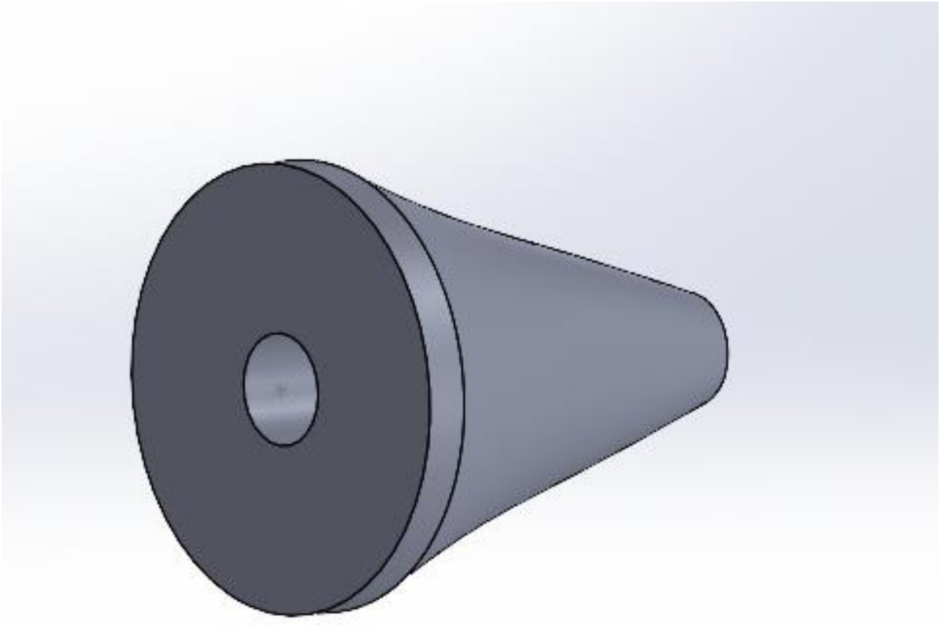
Despite potential cons, the Second-Generation model has been chosen as the final design for the Outdoor Air Quality Sensor



Design Timeline- First Generation Wiring Casing

First Generation:

- 3d printed wiring casing
- Cone-shaped to prevent water from entering the sensor
- 6mm through hole to pass wiring from exterior to sensor
- Attaches to the side of the sensor and interfaces with a drilled hole in the wood.



Iteration 1 Cons:

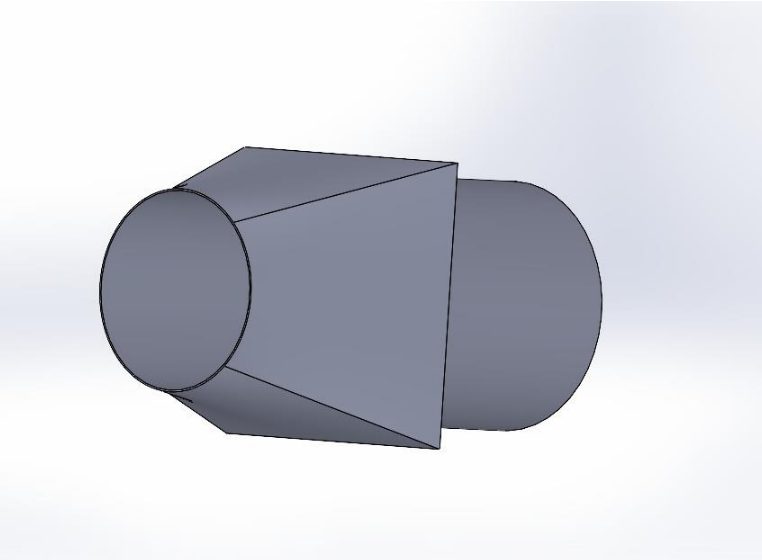
- Difficult to attach and create a seal with the exterior.
- Hole was not large enough to accommodate wiring adaptor

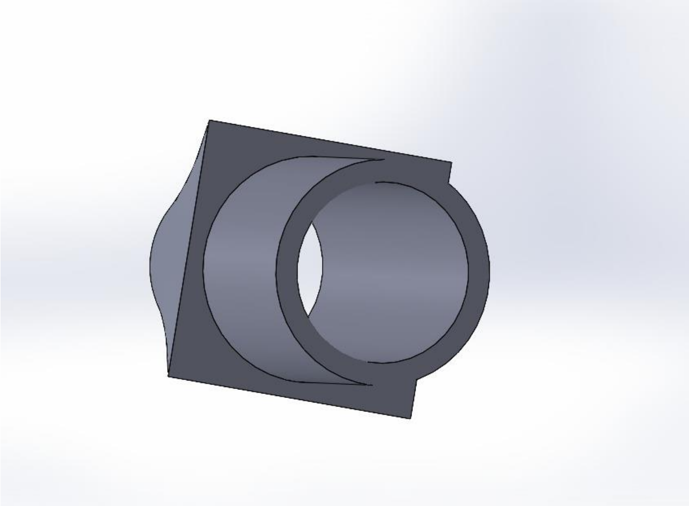
Timeline- Second Generation Wiring Casing

Second Generation:

- 3d printed pyramid with a cylindrical extrusion
- Larger dimensioned hole to allow both wiring and adaptor to pass through and connect to sensor.
- Extrusion allows the part to attach to sensor in a friction fit, creating a waterproof seal.

The second generation design has been chosen as the final model to include with the Outdoor Air Quality Sensor.

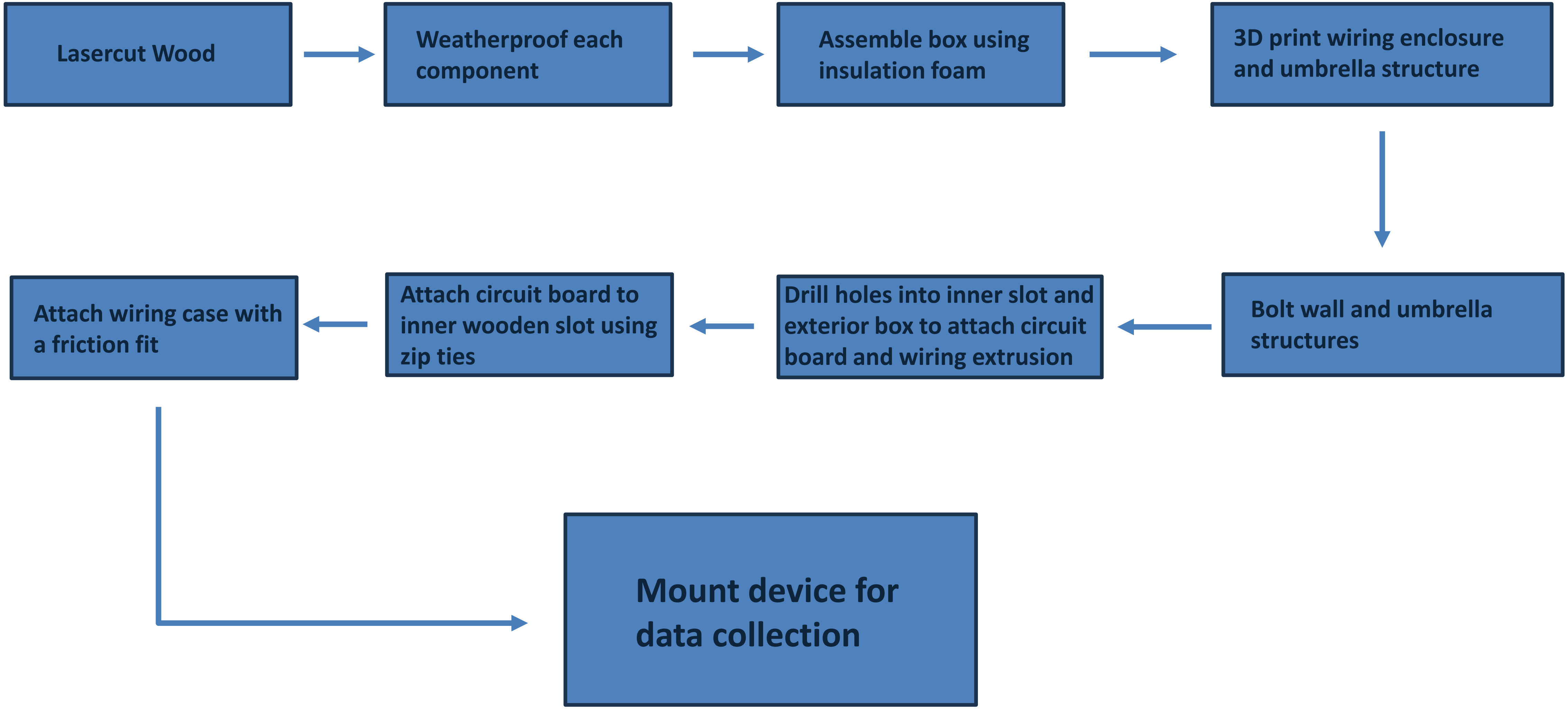




Testing

- ”Dishwasher Test”
  - Tested the outdoor air quality sensor’s resistance to heat and water.
  - Two 3D-printed sensors with identical dimensions were tested, one made of PLA and one of PET-G to test the durability of each material.
  - Both prints with the same weight underwent cycles in a Heavy-Duty Dishwasher in the same orientation.
  - Testing indicated that the umbrella structure outperformed the wall structure, especially in terms of resisting heat.
  - PET-G umbrella structure was chosen for the final model due to its overall superior performance in testing.

Final Manufacturing and Assembly Process



Costs

Final Pre-tax cost of a single Outdoor Air Quality Sensor:

Boron Particle Board	$65.31
Velcro Extreme Mounting Tape Strip	$0.67
PLA Material (~50 grams x $0.10/gram)	$5.00
Wood Material (⅛” plywood)	$1.00
Polyurethane Coating	$1.00
Miscellaneous Electronics	$25.00
Total	**$97.98**

Next Steps

Conclusions:

- Designing this sensor has expanded our capabilities in terms of collecting more diverse data that can be compared and analyzed to help monitor the efficacy of indoor ventilation systems on campus and work to improve them.

Future Goals:

- During the Fall 2024 semester, the project goal is to manufacture more stations and begin collecting indoor and outdoor air quality data from these stations in the Kendeda Building and other unique locations to understand how different environments at the same geographical location impact air quality.

Acknowledgments

Thank you!

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