CAED Temperature and Humidity Data Sensing

50095 Advanced Technology Applications in Construction

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1. Abstract:

This project utilizes Raspberry Pi technology to monitor and analyze temperature and humidity levels across three floors of the College of Architecture and Environmental Design (CAED). Using Raspberry Pi 3 with temperature and humidity sensors, data was collected to assess the impact of environmental conditions on occupant thermal comfort. The study found that while the mechanical systems effectively regulate temperature, humidity levels vary significantly, leading to fluctuations that could affect comfort. Floor 4 maintained the most stable temperature but had consistently low humidity, suggesting excessive drying from the heating system. Floor 3 exhibited the most variability in both temperature and humidity, indicating potential inefficiencies in air circulation. Floor 2 showed moderate fluctuations, likely influenced by window exposure and air movement. The study highlights the importance of integrated temperature and humidity control strategies to improve indoor comfort, and future work could expand on these findings by incorporating additional environmental sensors and longer-term data collection.

2. Introduction:

A Raspberry Pi is a relatively cheap and effective way to measure data by means of a small single board computer acting as a microprocessor. By connecting the Raspberry Pi's General Purpose Input/Output (GPIO) Pins to a number of different sensors to gather information like temperature and humidity, it is possible to easily obtain multiple data sets to compare how different spaces and their conditions can support (or hinder) the thermal comfort of its occupants.

With the acquisition of these data sets made possible, this project aims to compare, contrast, and gain insight as to how three different floors within the College of Architecture and Environmental Design measure up in providing an adequate level of thermal comfort to students who are required to spend a large amount of time within these spaces,

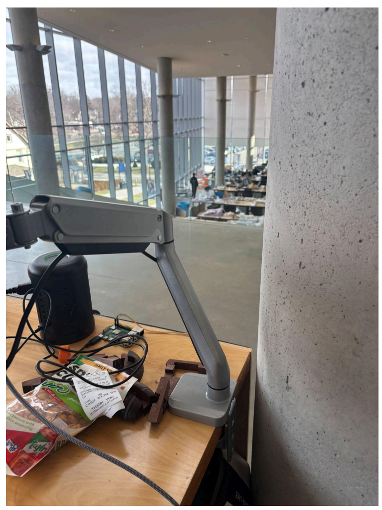
3. Team Members and Contributions:

Icarus	-	Coordinating Team & Equipment Setup
Aaron	-	Equipment Setup & Data Collection at Designated
Katelyn	-	Data visualization
Ethan	-	Data visualization
Luke	-	Data analysis, writing, and editing (Report)
Harris	-	Data analysis, writing, and editing (Report)
Sarah	-	Data analysis, writing, and editing (Report)

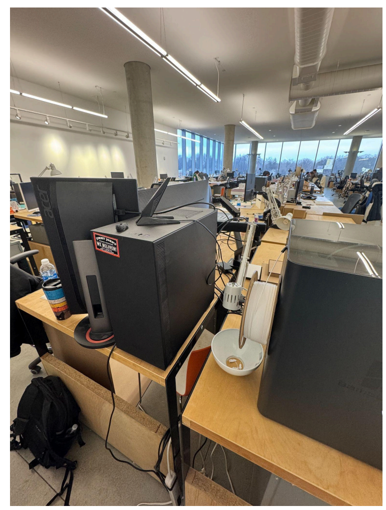
4. Location Selection and Justification:

The locations chosen reflect three different floors from the College of Architecture and Environmental Design. A different floor was chosen for each location in order to compare and contrast the temperatures and humidities measured at each level of the different studio spaces to find where the thermal comfort levels are or are not sufficient based on the mechanical systems, processes, and shading devices (or lack thereof) currently in place. As each member of the team spends a considerable amount of time across these various floors, it is vital that any inefficiencies are addressed to improve the comfort level of all occupants.

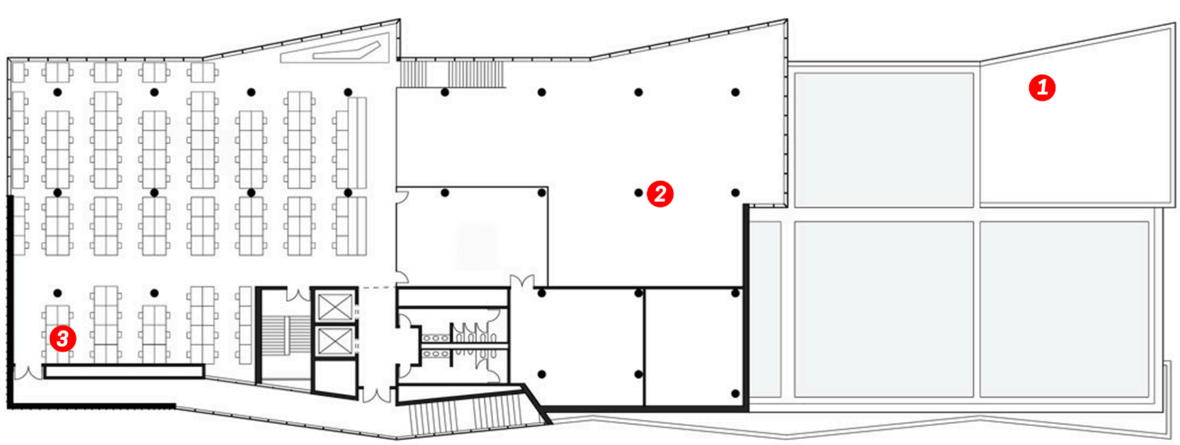
Second Floor Location 1



Third Floor Location 2



Fourth Floor Location 3



Location 1 - Second Floor

This location experiences the most daylighting, as it was positioned in close proximity to the large floor to ceiling windows, likely causing significant temperature and humidity fluctuations due to solar gains and heat loss. In Ohio, during the month of February, temperatures are low, and the quality of the window's insulation could greatly impact the indoor temperature. Additionally, the heated concrete floor can create a localized thermal environment, influencing the temperature readings at desk height. Finally, the minimal foot traffic nearby ensures consistent environmental conditions.

Location 2 - Third Floor

For this location, the sensor was placed in the middle of the room to provide a baseline for ambient conditions, as it is distanced from direct environmental influences like windows or heating sources. This location receives natural light but lacks direct solar exposure, allowing data collection for temperature and humidity reflective of the general room climate. Moderate foot traffic introduces variable heat from occupants, providing insights as to how human activity is affected by the building's thermal environment.

Location 3 - Fourth Floor

Finally, the location on the fourth floor was chosen due to its adjacency to a heating supply, making it ideal for analyzing the impact of HVAC systems on localized temperature and humidity. Corners often experience air stagnation, which can affect temperature distribution and moisture levels. Minimal foot traffic minimizes disturbances, ensuring data accuracy in capturing the direct influence of the heating source. This is important for understanding heat distribution patterns in the building and identifying potential thermal discomfort zones.

5. Experimental Procedure:

Step-by-Step Methods for Equipment Setup / Data Collection & Workflow -

1. Sensor Installation: Attach the temperature/humidity sensor to the Raspberry Pi 3.
2. Power Supply: Connect and power on the Raspberry Pi.
3. System Update: Update the Raspberry Pi to the latest software version to ensure compatibility and optimal performance.
4. Remote Access Configuration: Enable remote connection using RealVNC, allowing for convenient code uploads and monitoring.
5. Code Deployment: Upload the standard data collection code to the Raspberry Pi.
6. Data Collection Initiation: Start running the code to begin recording environmental data.
7. Data Collection Termination: Stop the code after the desired duration.
8. Data Backup: Copy the collected data and securely store it in Google Drive for backup and easy access.
9. Location Replication: Repeat steps 6 through 8 at each designated location:
10. Data Cleaning: Organize and clean the collected data to remove any errors.
11. Data Visualization: Create informative visualizations to present findings.

List of Equipment and Necessary Information:

1. Raspberry Pi 3: Used to collect and store temperature and humidity data from the sensor. It runs the data logging program and connects to the laptop for remote monitoring.
2. Temperature/Humidity Sensor: Used to measure the temperature and humidity at each location. It is connected to the Raspberry Pi for data recording
3. Laptop (Remote Access): Used to remotely access the Raspberry Pi to start or stop data collection and check that the sensors are working properly.
4. Google Colab/Python: Used to make graphs and identify patterns in the data, helping us understand how environmental conditions change in the building.
5. Google Docs: Used to document the data collection process, findings, and conclusions clearly and efficiently.

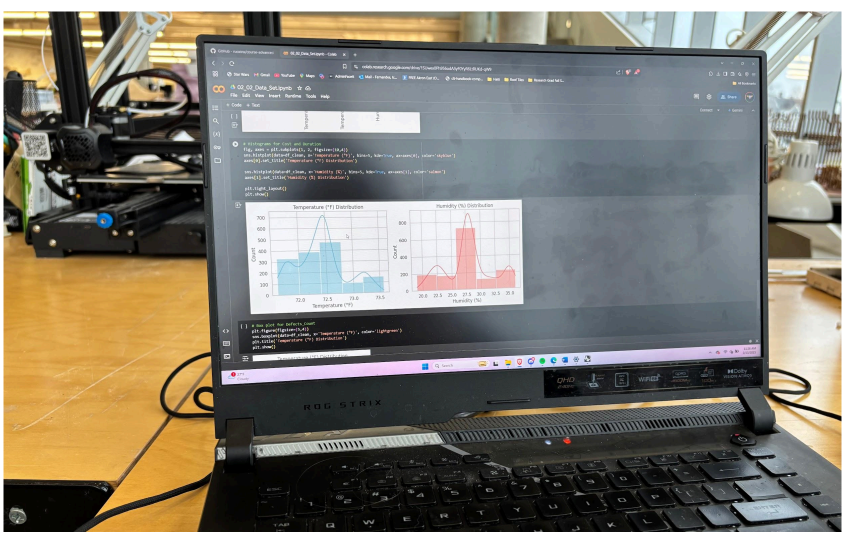
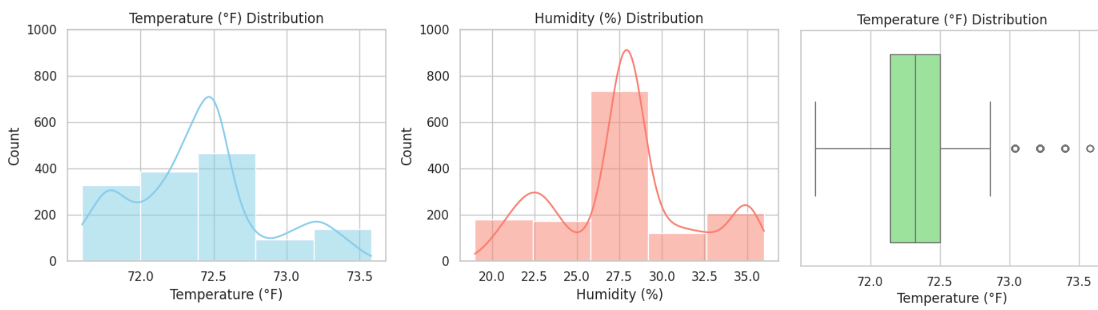


Fig. 5. *Data Collection Process.*

6. Data Collection and Analysis: Data Point & Average Temperature Distribution:

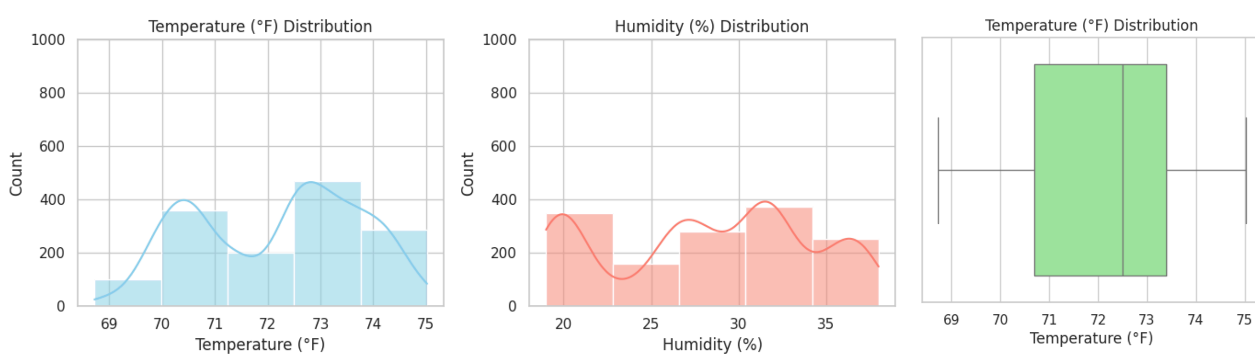
The first two graphs (blue & red) for each floor show the frequency of temperature data points within specific ranges, with bars representing the distribution. The overlaid trend line, based on linear regression, highlights the overall temperature trend and any significant patterns in the data. The second set of third visualizations (green) displays the average temperature across all data points collected in the studied spaces and provides an overview of the general thermal conditions within the environment to assess whether the temperature remains within a comfortable range throughout the observation period.

Floor 2



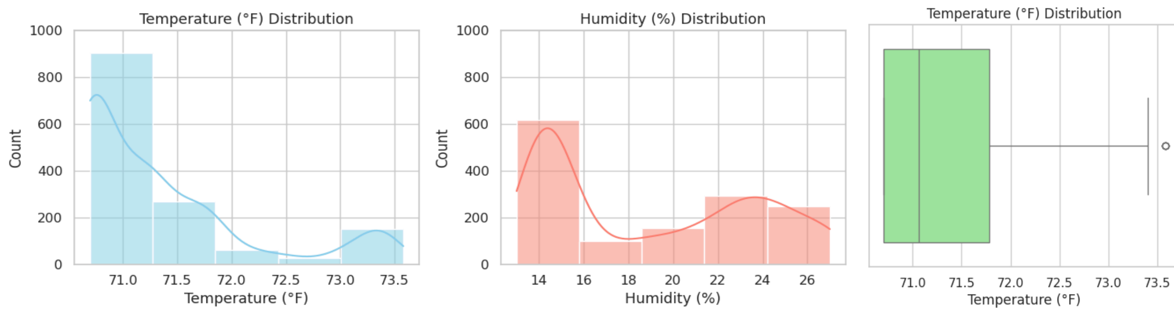
The temperature on Floor 2 remains stable, ranging from 71.8°F to 73.5°F, with most readings clustering around 72.4°F, indicating minimal fluctuation. In contrast, humidity varies more widely between 20% and 35%, with a peak around 28%, but occasional deviations at 21% and 35% suggest external influences like HVAC activity or occupancy changes. While temperature conditions appear consistent, humidity fluctuations may impact thermal comfort, highlighting the need for balanced environmental control.

Floor 3



The temperatures experienced on Floor 3 vary more than on Floor 2, ranging from 69°F to 75°F, with peaks around 70°F, 72°F, and 74°F, indicating moderate fluctuations. This suggests a less stable thermal environment, possibly due to external factors such as solar exposure or ventilation differences. Humidity levels range widely between 20% and 37%, with multiple peaks reflecting inconsistent moisture conditions. This variability in both temperature and humidity suggests that occupants may experience noticeable shifts in thermal comfort.

Floor 4



The temperature on Floor 4 is the most consistent of the three, ranging from 71°F to 73.5°F, with a strong peak at 71°F, indicating minimal fluctuation. This suggests a well-regulated thermal environment, likely due to its close proximity to the heating system. Humidity levels on this floor are significantly lower, ranging from 14% to 26% with a dominant peak around 15%, indicating a much drier environment. The consistently low humidity may contribute to discomfort, particularly in winter, where dryness can affect air quality and occupant well-being.

7. Conclusion:

Across all three floors, temperature remained relatively stable, with Floor 3 experiencing the most fluctuation, likely influenced by ventilation, solar exposure, or occupant activity. Floor 2 exhibited moderate stability, though minor variations occurred, potentially due to its proximity to large windows. Floor 4 maintained the most consistent temperature, likely due to its location near a heating source. Humidity patterns were far less predictable, with Floor 4 being consistently the driest, suggesting excessive drying from the heating system. Floor 3 displayed the most erratic humidity distribution, with multiple peaks indicating fluctuating ventilation or environmental inconsistencies. Floor 2 showed moderate variation, with occasional peaks possibly linked to changes in air circulation or external exposure.

A key finding is that while the mechanical systems effectively regulate temperature, they struggle with maintaining consistent humidity levels, leading to fluctuations that could impact occupant comfort. The significant variability on Floor 3 suggests inefficiencies in air circulation, while the extreme dryness of Floor 4 may present challenges in maintaining comfortable indoor conditions. These results highlight the importance of integrating both temperature and humidity control strategies to create a more stable indoor environment.

Throughout the process, a few challenges were faced, including ensuring accurate and consistent data across locations, particularly with external influences such as occupant movement and mechanical system cycling. Additionally, short-term fluctuations required careful analysis to distinguish meaningful trends from minor anomalies.

For future work, longer-term data collection could help identify seasonal trends and how HVAC adjustments impact indoor conditions over time. Exploring additional environmental factors, such as CO_2 levels or air circulation rates, could provide further insights into optimizing indoor comfort. Adjustments to HVAC settings, particularly in managing humidity, could improve overall environmental stability, ensuring that studio spaces remain both thermally comfortable and conducive to long-term occupant use. Furthermore, expanding the study to additional campus buildings could provide a broader understanding of environmental trends across different architectural conditions.

8. Appendices:

Code for Data Collection

- Raspberry Pi Sensor Code

Code for Data Visualizations:

- Google Colab Visualizations

Raw Data Files:

- Floor 2
- Floor 3
- Floor 4