ADDRESSING A

Multi-Billion Dollar CHALLENGE

Advancing Knowledge of How High-Quality School Environments Can Positively Affect Educational Outcomes

FINAL REPORT | DECEMBER 2023

APPENDICES

Study Replication Resources

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APPENDIX C

Indoor Environmental Quality Replication Resources

- List of Sensors
- Training and Deployment Guide
- Sensor Location Selection
- Occupancy Tracker
- Sample Data Summary

Replicating the Indoor Environmental Quality (IEQ) on-site measurement portion of this study should consider the following.

Step 1: Determine the factors to measure

The first thing to do before beginning a study of IEQ is determine what factors are of interest. As was done for this study, it is recommended that the factors selected for study fall under the four main categories of IEQ: thermal comfort, air quality, acoustics, and daylight. Selecting factors within each category will depend on the available resources and technology, the level and length of access provided to the schools, who is available to assist with data collection, and what may be a priority interest to the school/district, themselves. For more information on the factors studied and tools used for this study, see the List of Sensors under the IEQ Replication Resources section.

Step 2: Identify spaces

Once it is known *what* is being studied, the next step is to determine *where* the IEQ factors will be studied. Deploying IEQ sensors across an entire school is oftentimes impractical and unnecessary. Akin to this study's approach, the researchers recommend identifying a handful of "typical use" spaces to capture a sense of the schools' average conditions. For more recommendations on this step, see the Sensor Location Selection document under the IEQ Replication Resources section.

Step 3: Prepare the toolkits and train people for deployment

Once the *what* and *where* are determined, the *how* and *who* can be planned. This is also the time for IEQ sensor identification and acquisition and the training of data collectors. Depending on the scope of study, a team could collect data within as little as one week with just a few sensors if the research takes place in one or two schools. But if the scope is larger, as with a district-wide study, more planning and greater detail is necessary to decide (1) the number of sensors needed and how many can be available at one time, and (2) how many weeks they need to be deployed to complete the data collection. If a multi-week study is necessary, establish a data normalization process to ensure that any exterior temperature variations during the data collection timeframe can be accounted for in the data tracking and analysis.

There are several options for acquiring IEQ sensors. If the research team does not have its own tools to deploy, a nearby university with an architecture or building science program, or even the local utility company, may have a tool-lending or rental library. If the researchers have their own tools, it is important to prepare the sensors following the manufacturers' instructions to calibrate them properly in advance of the study. Each sensor should also be labeled with a unique identifier, so it is easy to determine what tool was placed in which space, particularly for data download.

A team of individuals may be needed to help deploy the sensors, depending on the scale of the study. During a week-long study, one individual may be able to cover two schools, depending on their proximity to the schools. However, it often becomes challenging for one person to reach much more than two schools without disrupting the schools' instructional hours. No matter how many assistants are involved, it is helpful to gather everyone together alongside the toolkits before the study begins to walk them through each step of the Training and Deployment Guide, found under the IEQ Replication Resources section, to ensure everyone knows how to prepare and deploy the tools properly.

Step 4: Prepare the schools for deployment

When coordinating data collection within schools, the research team should work with a person from each participating school to help identify typical classrooms and coordinate dates and access to the school for data collection. Before that happens, the research team should inform a broader school audience that the study is occurring. In particular, the team should communicate in advance with every teacher occupying each room selected for the study. A summary should be provided to these teachers, perhaps in an email sent by the school's principal, which outlines the purpose of the study, the tools that will be deployed, and how it might impact them and their students. Involving the teachers is crucial to proper data collection; otherwise, sensors could be turned off, moved around the room, or even returned to the main office.

To minimize impact during school instructional hours, most of the tools selected for this study are data-logging, meaning they can be left unattended in a classroom and collect data over time. Typically, sensors are deployed outside of school hours, either before class begins in the morning or after school lets out in the afternoon. The data collector may have

to arrive at the school an hour or more before classes begin on the first day of the data collection period to successfully deploy all the sensors, which makes for an early morning. Thus, it is important to coordinate with each school's point-of-contact so the data collector can get into the building that early and gain access to the necessary spaces.

Step 5: Deploy the tools

Once everything has been coordinated, the sensors can be deployed. Follow the Training and Deployment Guide under the IEQ Replication Resource section for more information.

During deployment, the researchers recommend the following for each room being studied.

- Make sure the researchers have coordinated with each teacher who occupies that room. If the teacher(s) are in the room when the sensors are being deployed, make sure they understand the study and their role in it.
- If the research team is interested in tracking occupancy to more closely analyze the data, ask the teachers in each room to complete an Occupancy Tracker (available under the IEQ Replication Resources section).
- Properly place the sensors, making note of which sensors are being placed in which locations so the data can be easily tracked after the fact.
- The researchers should also leave a business card next to each sensor, alongside a document that briefly outlines the study and what the sensors are measuring. That way, if anyone has any questions, they can call the research team directly.
- The sensors should be checked at least once each day during deployment to ensure they are still working as expected and that nothing has been moved or unplugged. The team should coordinate the time and access for this check-in before the study begins. In some cases, they can arrange with someone at the school to perform the check, such as a maintenance or facilities supervisor, as long as that person is trained in how to do it.

Step 6: Download data and analyze results

Once the data collection period is complete, collect all sensors and download the data to a central location. Each sensor will have a different interface, and ultimately there may be a variety of spreadsheets from each sensor. It is best to group the data by room and then aggregate the per-room data into one spreadsheet to create a summary (refer to the IEQ Replication Resources section for a sample data summary). Analysis of the data may involve things like separating and comparing data of occupied versus unoccupied conditions, averaging data, and visualizing information for easy comparison.

IEQ Replication Resources

To help replicate this study's Indoor Environmental Quality on-site measurements, the following resources are available herein:

- IEQ — List of sensors
- IEQ — Training and deployment guide
- IEQ — Sensor location selection
- IEQ — Occupancy tracker
- IEQ — Sample data summary

List of Sensors

	Tools Used		Unit of Measure
THERMAL COMFORT			
Air Temperature	HOBO MX1102A		deg F
Humidity	HOBO MX1102A		% RH
Air Speed	Degree Controls F350-omni with HOBO (UX120-006M)		FPM
Mean Radiant Temperature	ping-pong with HOBO (UX120-006M) and external sensor (TMC6-HD)		deg F
AIR QUALITY			
CO_2	HOBO MX1102A		ppm
PM10/2.5	PurpleAir PA-II		ug/m3
ACOUSTICS			
dBA	Tenma 72-947		dB
LIGHT			
illuminance	Extech EA33		footcandles
glare	Manual phone app + grasshopper script for false color imagery		lux ratio
NORMALIZATION			
occupancy	HOBO UX90-006		time
occupancy	tracked by teacher	See the Occupancy Tracker in Appendix C	time
weather station	HOBO U30 USB Weather Station Starter Kit, 2-meter tripod, PurpleAir PA-II		deg F, % RH, MPH, ug/m3

Training and Deployment Guide

The night before you begin a study, complete the following:

- Calibrate the HOBO MX1102A
- Launch the HOBO MX1102A, HOBO UX90-006, and HOBO Data Logger by setting them to a Delayed Start
- Verify that the batteries in the Tenma have been fully charged and have the correct time.

When you place your sensors at the beginning of every week, please complete your worksheet to locate which sensor was placed in which room for the duration of the study.

You will be using the following sensors to study data in the below spaces in each school:

- Classroom 1
  - HOBO MX1102A (CO2, temperature, humidity)
  - Tenma 72-947 (dBA)
  - Mounted to tripod:
    - PurpleAir PA-II SD (PM 2.5/10)
    - HOBO data logger + grey globe + anemometer (Mean Radiant Temperature + Air Speed)
- Classroom 2
  - HOBO MX1102A (CO2, temperature, humidity)
  - Tenma 72-947 (dBA)
- Classroom 3
  - HOBO MX1102A (CO2, temperature, humidity)
  - Tenma 72-947 (dBA)
- Classroom 4
  - HOBO MX1102A (CO2, temperature, humidity)
  - Tenma 72-947 (dBA)
- Cafeteria
  - HOBO MX1102A (CO2, temperature, humidity)
  - Tenma 72-947 (dBA)
  - HOBO UX90-006 (occupancy)
  - Please note that for the cafeteria, the occupancy tracker should be mounted to the wall (see instructions for more details), but the CO2 and Sound Meter should be placed in a location that is controllable by teachers. This will need to be determined on a case-by-case basis, and may not always be the "Ideal" placement as laid out in the instructions below. Please note the location of these devices on a floor plan for future reference. The priority is to ensure that these devices will not be disturbed during the length of the study.

You will be given a card for each room to explain the sensors and the study. Please make sure to locate this near the sensors, along with your business card.

Air Temperature/Humidity/CO2 – HOBO MX1102A

A complete user manual for this logger can be found here:
https://www.onsetcomp.com/resources/documentation/22504-mx1102a-manual

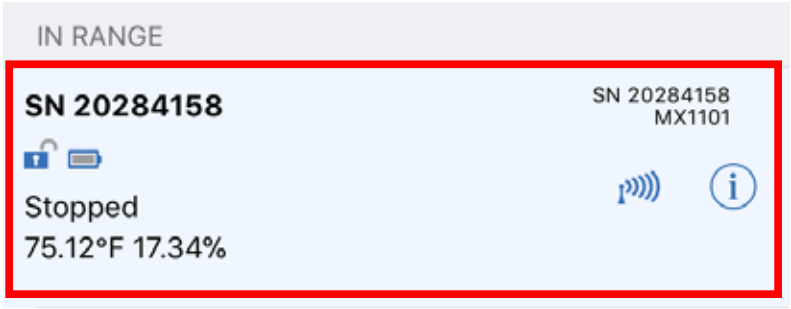
The following are PE's recommended steps for setting up this logger:

- Download HOBOconnect from the app store onto your phone or tablet
- Ensure that batteries are installed in the logger. Open the battery door on the back of the logger and insert four AA batteries if needed.

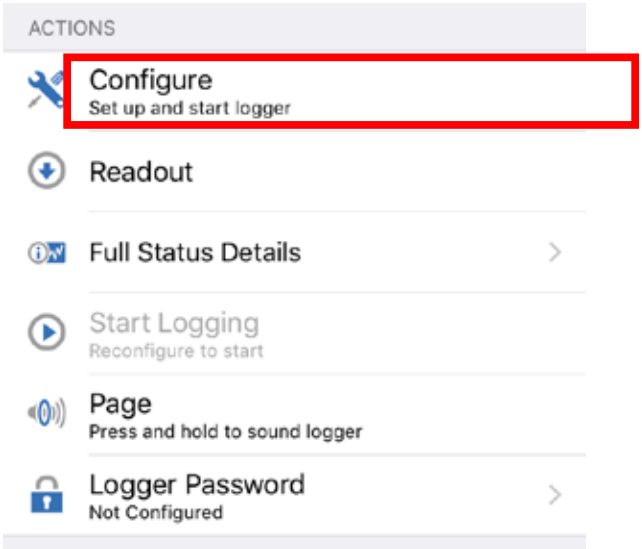
STEP 1 – CALIBRATE THE DEVICE (should occur the night before the study)

- Open HOBOmobile. Enable Bluetooth in your device settings if prompted. Bluetooth must be enabled on your device and in range for setup.
- In HOBOmobile, tap the HOBOs icon in the bottom left. The logger should appear in the In Range list.

- Tap the row in the In Range list associated with the logger number found on the bottom of the device to connect to the logger.



- Once connected, tap Configure to set up and start the logger.



- Choose the following logger settings: Set logging interval to 10 minutes, set the Start Logging time to Now, and set Stop Logging to When memory fill or On button push.
- Click Start at the top of the screen to deploy the logger.
- Once deployed, take logger to an empty room or outdoors to leave for calibration.

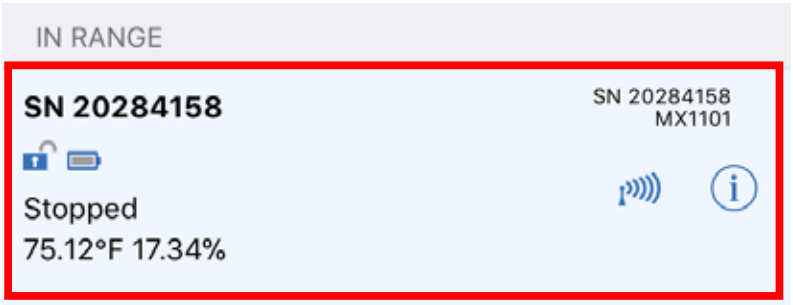
- Press and hold the “Calibrate” button at the right of the bottom of the screen until you hear a loud beep. Release the button.

- Leave the logger in place until calibration completes, about 5-10 minutes. Step out of the room to ensure your breath does not affect the calibration.
- Once calibration is complete, you will no longer see the “Calibrate” flashing in the bottom right, and the numbers on the screen will not be changing as quickly. Stop the logger by pressing and holding the bottom left button until the logger has been stopped.
- Proceed to launching the device after calibration is complete.

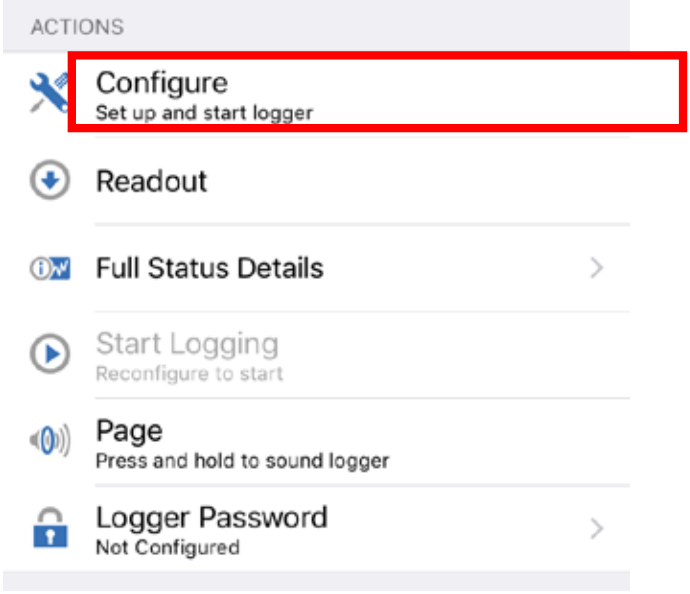
STEP 2 – LAUNCH THE DEVICE (should occur the night before the study)

- Open HOBOmobile. Enable Bluetooth in your device settings if prompted. Bluetooth must be enabled on your device and in range for setup.
- In HOBOmobile, tap the HOBOs icon in the bottom left. The logger should appear in the In Range list.

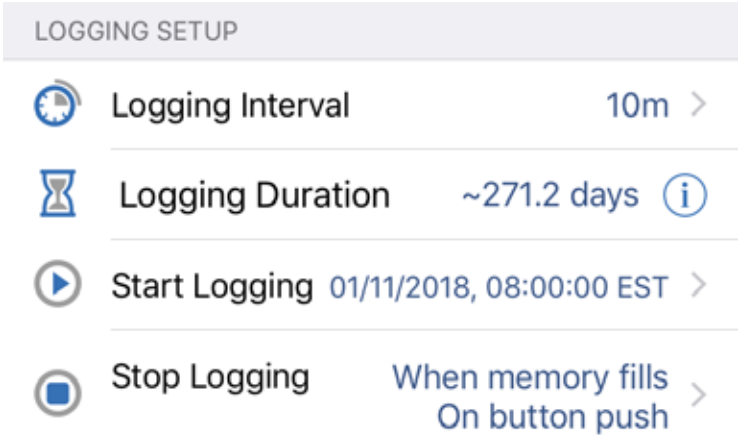
- Tap the row in the In Range list associated with the logger number found on the bottom of the device to connect to the logger.



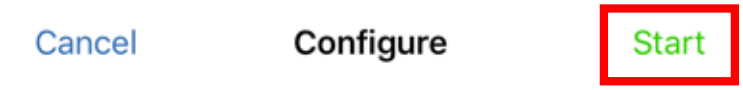
- Once connected, tap Configure to set up and start the logger.



- Choose the following logger settings: Set logging interval to 10 minutes, set the Start Logging time to be when you expect to deploy the sensors on your first day of testing, and set Stop Logging to When memory fill or On button push.



- Click Start at the top of the screen to deploy the logger.

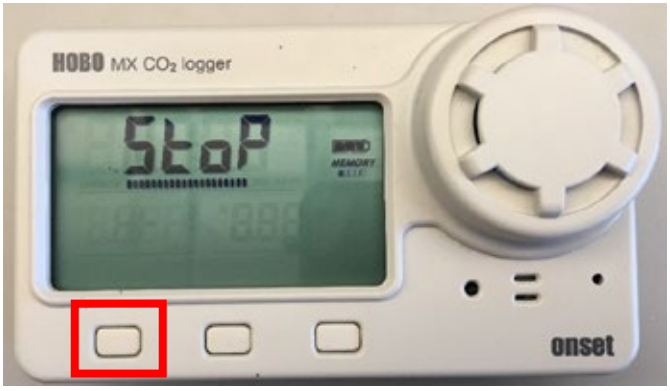


STEP 3 – PLACE THE HOBO

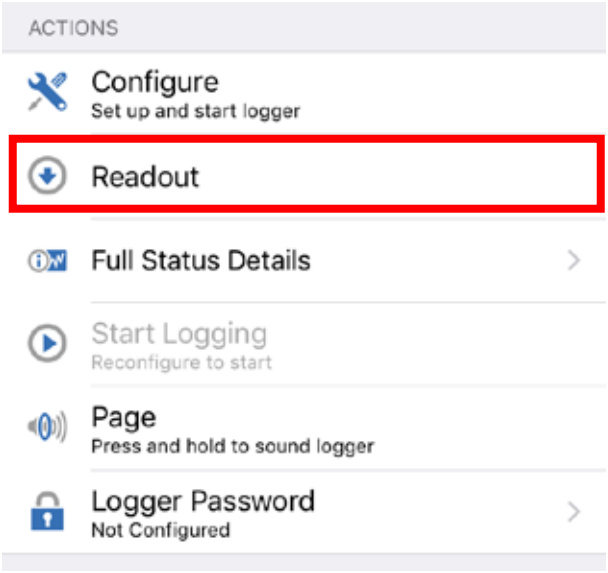
- On your worksheet, make a note of which room the HOBO is being placed in for the study.
- Place HOBO in data-collection location. Sensors should be placed face up or out so as not to block the sensing locations on the device. Place the sensor within the breathing zone (3 ft – 6 ft), away from HVAC equipment, away from windows, and in an area it will not be disturbed by occupants whenever possible. For example, a good location in a classroom is generally on the teacher's desk.

STEP 4 – UNLOAD THE DATA

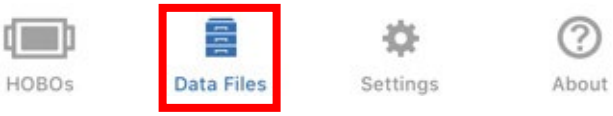
- To Stop deployment, hold down the bottom left button on the reader until the screen says STOP.

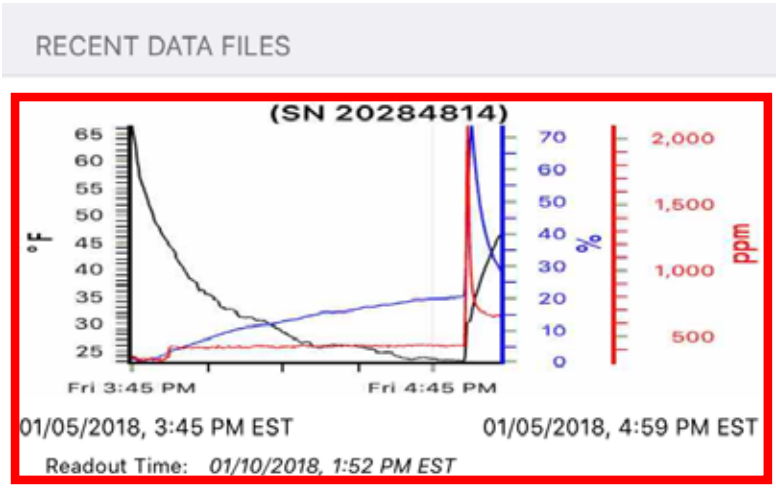


- To offload data from the logger, return back to the HOBOmobile app, connect to the logger, and tap Readout. The data from the logger will be saved to your device.

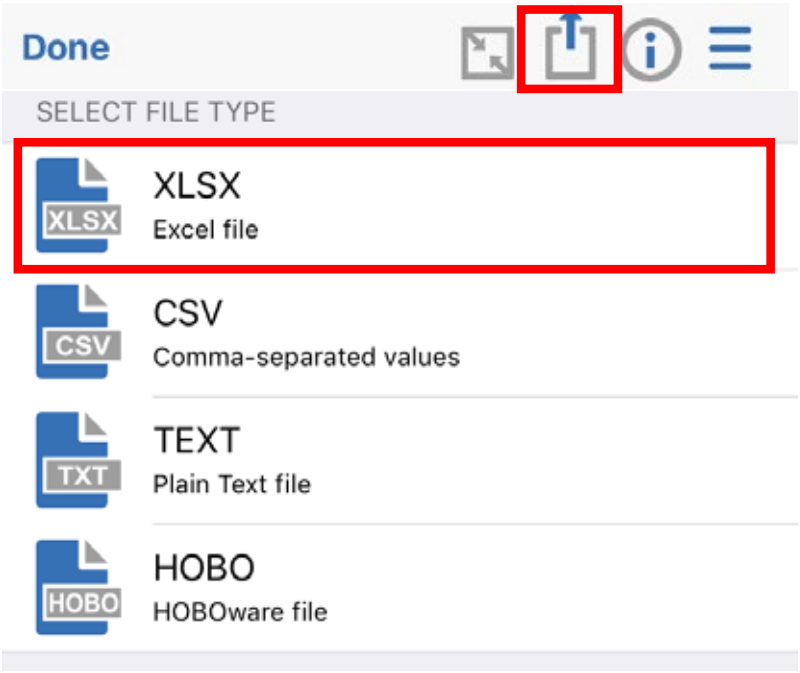


- Tap the Data Files icon at the bottom of the screen and then tap the mini-graph to view a larger version of the graph.





- Tap to export the data to an excel file and e-mail the data to yourself.



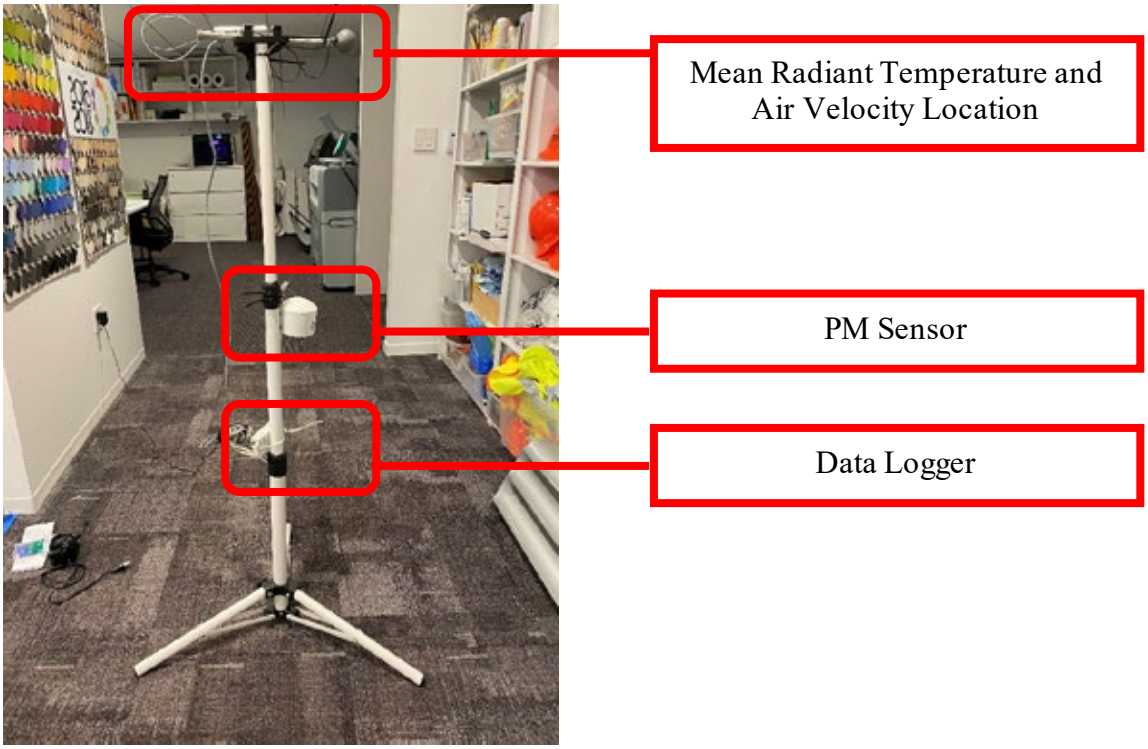
- Tag this data file with the following criteria: **Temp_SCHOOL NAME_ROOM Number.xlsx**, and store it in the project folder.

Indoor Air Quality Tripod

The Indoor Air Quality Tripod has 4 sensors mounted on it: Air Velocity, Mean Radiant Temperature, Particulate Matters (PM Meter), and Data Logging. A more detailed explanation for each of the devices will be given below. For setting up the tripod, there are two possible configurations: Deployed Mode, and Compact Mode, which can be adjusted by screwing and unscrewing the black screws in between the metal tubes.

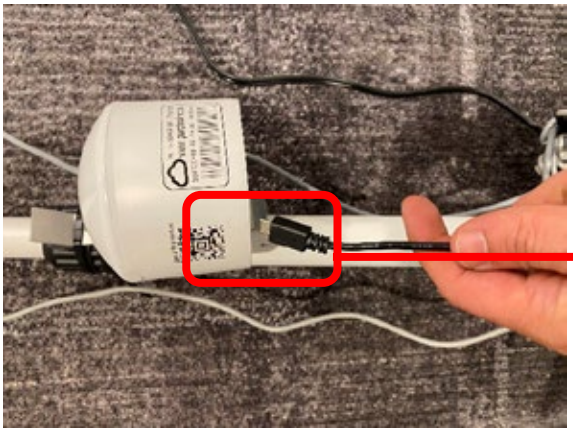
- The Compact mode, should be used when carrying the tripod to the site and from the site, and it should look like this:

- Please protect the sensors at the top when transporting
- The Deployed Mode is used when the sensors are tracking any data, and should look like the image below



- Make sure that every time you collapse or deploy the tripod, you use the black screw to tighten the metal tubes (there might be sensors attached to these black screws; it is OK to twist the black tubes with the sensors attached to them). DO NOT TWIST THE METAL TUBES at the moment of deploying or collapsing the tripod:

- The only cable you are going to need to plug into the sensors is the PM Meter's power chord. Please make sure to connect this cable once the tripod has been deployed, and unplug it before collapsing it.



Chord is supposed to be connected to PM sensor after deployment and before collapsing

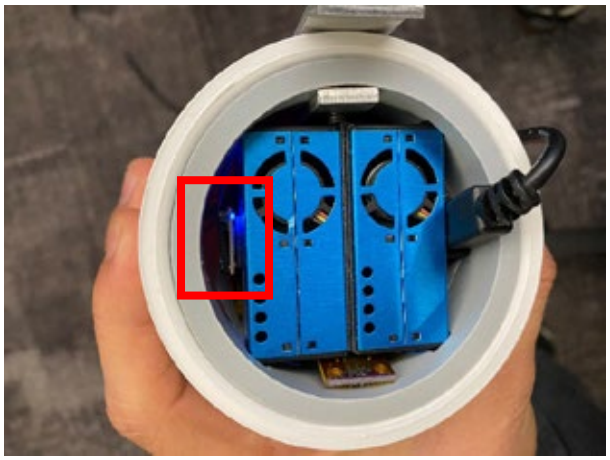
PM 10/2.5 – PurpleAir PA-II SD

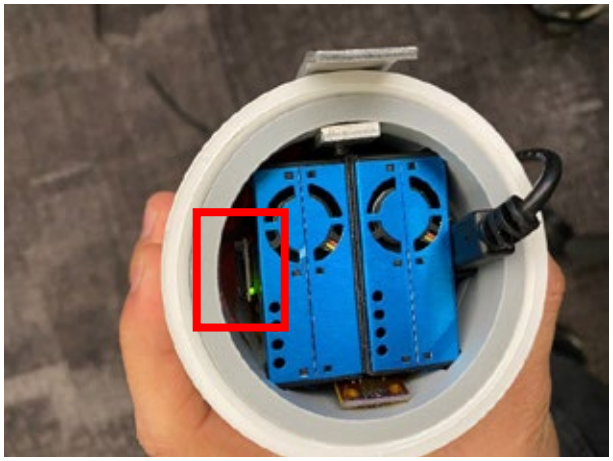
This sensor is attached onto a tripod with a series of other loggers. This tripod should be located out of the way of classroom activity to avoid interference by students, but also away from windows, doors, and diffusers whenever possible.
Please communicate to the teacher that this device should remain plugged into the wall AT ALL TIMES during the study.

The following are PE's recommended steps for setting up this logger:

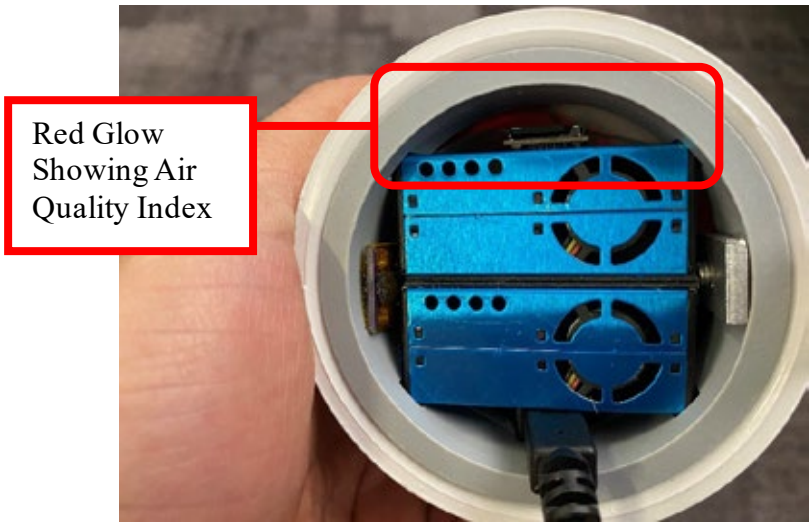
STEP 1 – LAUNCH THE DEVICE

- Plug the power block into a functioning wall outlet.
- A blue and green light seen from the top of the sensor indicates the sensor is starting.



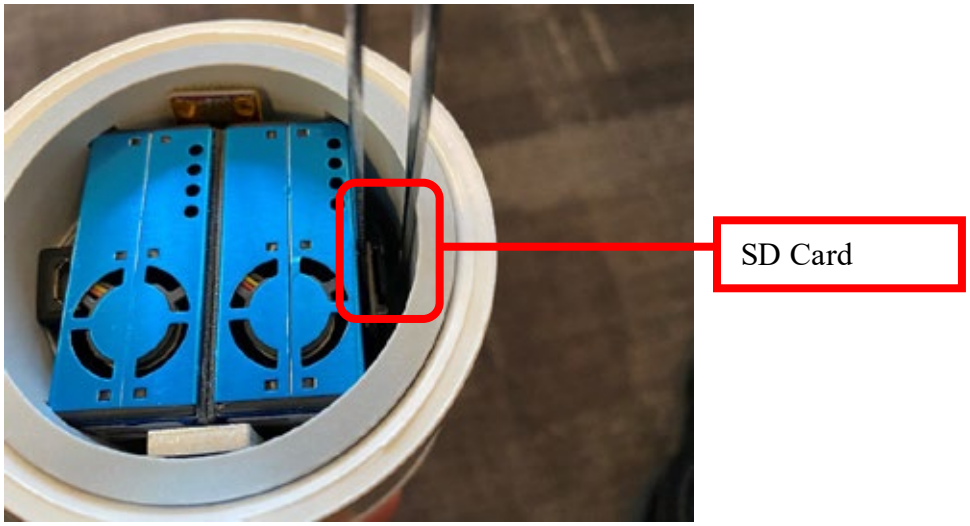


- After 10-15 seconds both lights should turn off and will begin to glow the current AQI color shortly. Make sure the blue LED light next to the SD card flickers from time to time (approximately every 2 minutes)

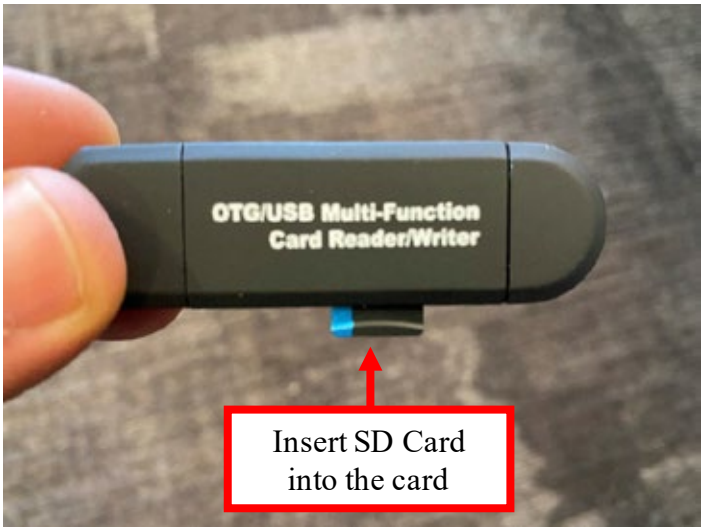


STEP 2 – UNLOAD THE DATA

- To stop the device, all you need to do is unplug it from the wall.
- To unload the data, utilize the tweezers to remove the microSD card from the device.



- Connect the SD card into your SD card reader, and plug into your computer. Once connected, locate the CSV files on the device. Tag this data file with the following criteria: **PM _SCHOOL NAME_ROOM Number.csv**, and store it in the project folder.



- After data has been downloaded in this location, please notify the Sustainability Team for review.
- After data review has been completed, please delete the content of the SD card, and reinsert the SD card into the slot in preparation for the next launch. To reinsert the SD card properly, the logo should face toward the outside of the device and the magnetic contacts face inside toward the sensors, or up as shown in the image below.

Air Speed – Degree Controls F350-omni

- This sensor is attached onto a tripod with a series of other loggers. This tripod should be located out of the way of classroom activity to avoid interference by students, but also away from windows, doors, and diffusers whenever possible.
- For setup, please ensure that this sensor is plugged in to the #1 and #2 channels of the HOBO data logger and follow the instructions under Mean Radiant Temperature to ensure that device is properly launched and connected.
- The sensor head is an omni-directional air speed sensor. This means it can be installed to face any orientation and pick up air speeds from any direction. However, the inside of the head is very sensitive, so please be careful during transport and placement to not damage this sensor.

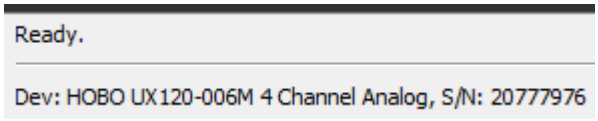
Mean Radiant Temperature – HOBO Data Logger with Grey Globe

- This sensor is attached onto a tripod with a series of other loggers. This tripod should be located out of the way of classroom activity to avoid interference by students, but also away from windows, doors, and diffusers whenever possible.
- Please communicate to the teacher that this device should remain plugged into the wall AT ALL TIMES during the study.
- A complete user manual can be found here: https://www.onsetcomp.com/files/manual_pdfs/17384-E%20UX120-006M%20Manual.pdf

The following are PE's recommended steps for setting up this logger:

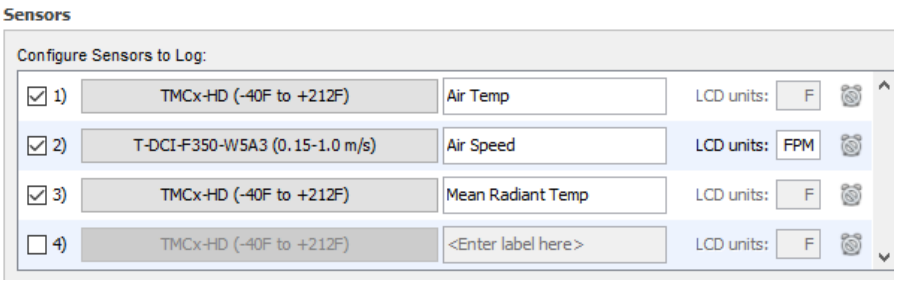
STEP 1 – LAUNCH THE DEVICE (Should occur the night before the study)

- Connect the HOBO Data Logger to your computer using the USB cable.
- Open HOBOware
- If you see the HOBO information in the bottom left corner of the HOBOware screen, you will know that the device has been recognized by the software and you can proceed with the launch.

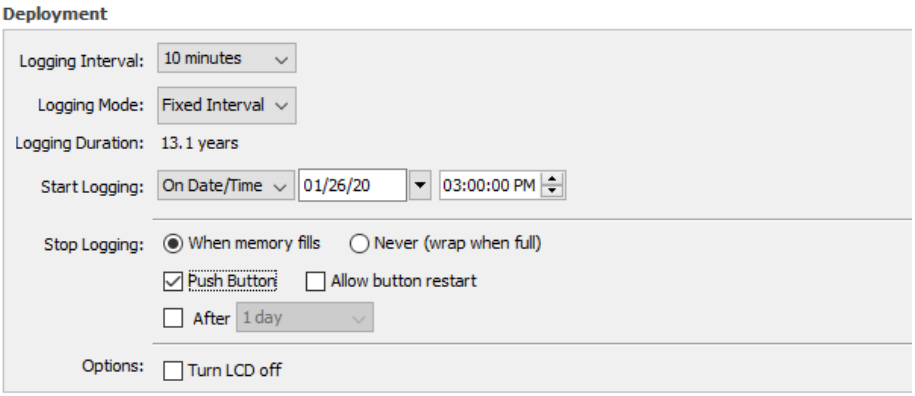


- Click the "Launch" button at the top of the screen.

- Under the "Sensors" section, select the first three sensors and label as follows. Sensors 1 and 3 can be found under Temperature, and Sensor 2 can be found under Air Velocity.



- Under "Deployment", set the logging interval to 10 minutes. Set the Start Logging to On Date/Time, and select the time that you plan to start the study the following day. Under Stop Logging, select When Memory Fills and Push Button.



- Once complete, press Delayed Start at the bottom right to launch the device.

STEP 2 - PLACE THE DEVICE

- The device is mounted to a tripod, which should be set up on the edge of a classroom, out of the way from activity to avoid interference by students. Behind the teachers desk may be an appropriate location. Please try to play away from the windows, door, and/or directly underneath a diffuser whenever possible.
- Once the tripod is in place, make sure that both plugs are plugged into the wall and tape down wires as necessary.
- If the teacher is there, please inform them that this tripod should remain plugged in during the entire length of the study!

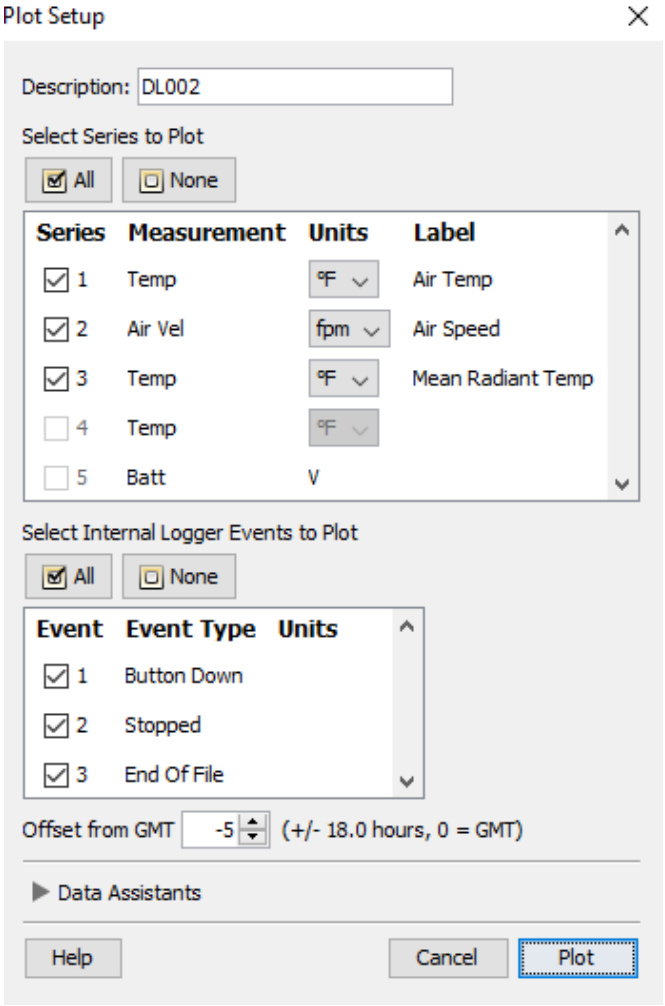
STEP 3 – STOP THE DEVICE

- To stop the device, press and hold the top left button on the device until STOP appears across the screen.

STEP 4 – DOWNLOAD THE DATA

- To download the data, reconnect the HOBO Data Logger to your computer and open HOBOware.

- Once the device has been recognized, select the Readout device button at the top left of the screen.
- Locally save the HOBO file to continue.
- A Plot Setup screen will appear. Make sure the three data points are properly identified – Air Temp, Air Speed, and Mean Radiant Temp. At the bottom of the screen, select Plot.



- The data will then plot out onto the screen.
- Select File > Export Table Data, and click Export.
- Save this data file with the following criteria: **Thermal Comfort _SCHOOL NAME_ROOM Number.csv**, and store it in the project folder.

dBA – Tenma 72-947

A complete user manual can be found here:
http://www.farnell.com/datasheets/1842860.pdf?_ga=2.129813132.1086292094.1517276643-259333521.1517276643

The following are PE's recommended steps for setting up this logger:

STEP 1 – PLACE THE SOUND METER

- On your worksheet, make a note of which room the sound meter is being placed in for the study.
- The sound meter is battery powered. Please make sure to charge and replace the batteries in the sound meter every day.

STEP 2 – LAUNCH THE DEVICE

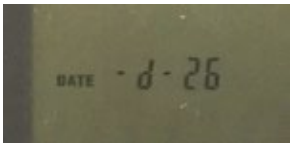
- First, turn on the device by pressing the bottom right power button.
- Above the dBA reading, verify that the device is set to the correct time. If the time is correct, please proceed to the next bullet. If not, follow the sub-bullets below to correct the time.

- TO CHANGE THE TIME, Press and hold the "Setup" button and then press the yellow power button for ~2 seconds. Release both buttons.
- You should see Time flash on the screen, and then the following screen. Press the "Setup" button to advance to the next screen.

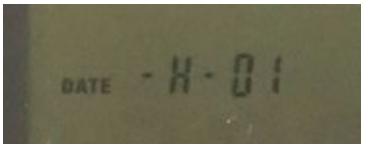
- The next screen should show numbers and nn on the bottom. The numbers represent minutes. Press the "Level" button until the screen reads the appropriate time in minutes. Once there, press the "Setup" button to advance to the next screen.

- The next screen shows a number at the top and h – A or P. This represents the hours in AM or PM. Press the "Level" button until the screen reads the appropriate time in hours, and keep scrolling to make sure that AM/PM matches. Once there, press the "Setup" button to advance to the next screen.

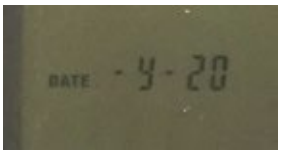
- The next screen shows the date. Press the "Level" button until the screen reads the appropriate day of the month. Once there, press the "Setup" button to advance to the next screen.



- The next screen shows the month. Press the "Level" button until the screen reads the appropriate month of the year. Once there, press the "Setup" button to advance to the next screen.



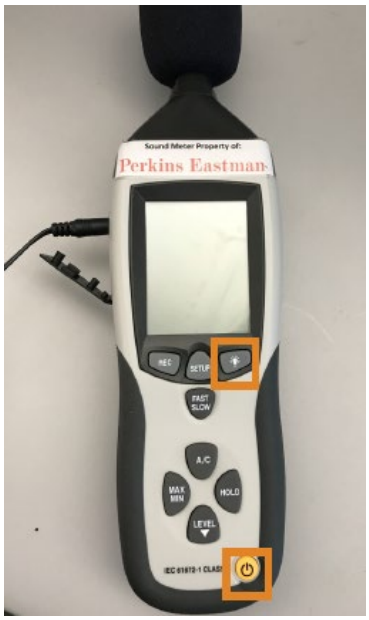
- The next screen shows the year. Press the "Level" button until the screen reads the appropriate year. Once there, press the "Setup" button to advance to the next screen.



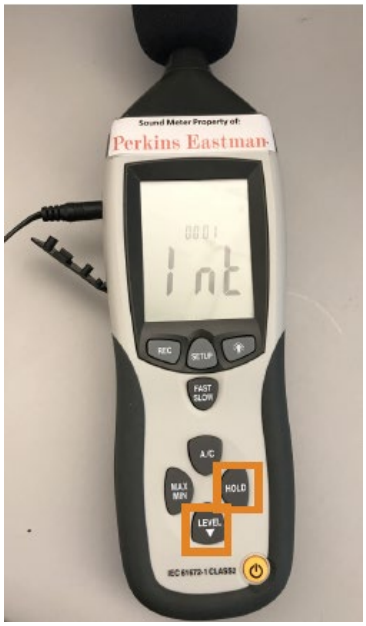
- The next screen says Reset. To confirm the settings, press the "Setup" button one last time to advance to the final screen.

- The final screen should show the appropriate date as you have entered, YR – MO – DAY. Press the "Hold" button to lock these settings and return to the main screen.

- The main screen should now show the appropriate time just above the dBA reading. Once complete, power the device off by holding the yellow power button for 3 seconds.
- ONCE YOU HAVE CONFIRMED THE TIME IS CORRECT, Press and hold the "Light bulb" button and then press the yellow power button for ~2 seconds. Release both buttons.

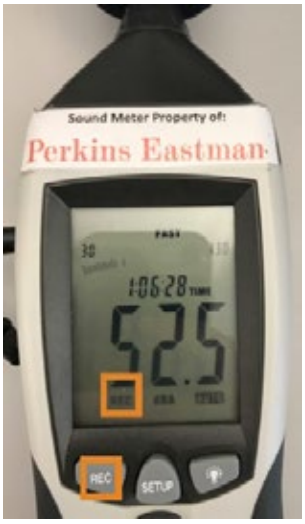


- Set interval to desired number of seconds (45) using the "LEVEL" button. Press "HOLD" button when finished.



- Use the "LEVEL" button to change the decibel range. Choose "30-130" as range. Confirm that the small clock icon does not appear in the lower lefthand corner of the screen. If the icon appears, press the "Setup" button to disable the automatic power off feature.

- Press the "REC" button once to start the recording. "REC" should appear in the bottom right corner of the screen. Meter is ready to collect data.

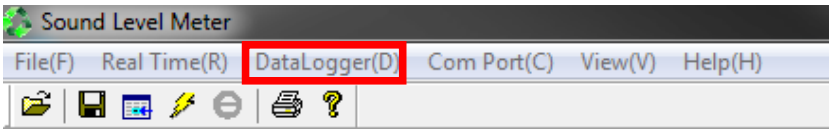


STEP 3 – DATA COLLECTION PERIOD

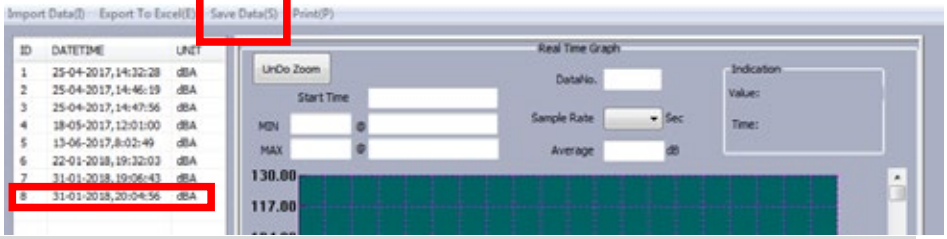
- While data collection is occurring, return to the device each day to ensure data is still collecting. At this time, press and hold the power button for 3 seconds to turn off the sound meter. This will log the data collected during the previous day.
- Once the meter is off, please replace the battery with a freshly charged reusable battery.
- Repeat Step 2 to relaunch the device for a new day of data collection.

STEP 4 – UNLOAD THE DATA

- At the end of the data collection period, you must press and hold the power button to turn off the sound meter **BEFORE** removing the batteries or data will not save.
- To unload the data, connect the sound meter via USB to your computer, turn on the Sound Meter, open the Sound Level Meter application, and click the Setup button on the meter to connect.
- Press the Datalogger (D) button.



- Select (doubleclick) the datapoints that match up with your recording time period (there should be 3-4 different data files from your week of study, depending upon how many times the sound meter was restarted) and click Save Data to export a .txt file.



- Open the .txt file in notepad and delete the first row – the header information
- The .txt file can then be imported into excel for analysis by opening Excel, selecting the Data tab, Get Data, From File, From Text/CSV. Select your .txt file when prompted.
- The pop-up window will prompt you how to read the text file. Select "Comma" as you Delimiter, and the data should separate into individual columns showing Date, Time, dBA reading, and unit respectively.

- Tag this data file with the following criteria: **Sound_SCHOOL NAME_ROOM Number_DATE of recording.csv**, and store it in the project folder.
- After data review has been completed, please clear the sound meter by holding the "REC" button and then press the yellow power button for ~2 seconds until the screen says CLR. This means the device has been successfully cleared, and you can release both buttons.

Occupancy – HOBO UX90-006

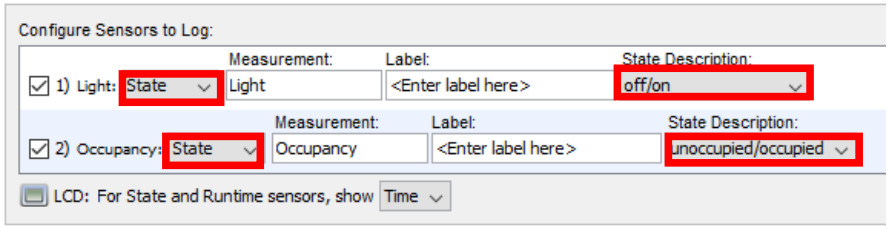
A complete user manual can be found here: https://www.onsetcomp.com/files/manual_pdfs/15433-H%20UX90-005%26006%20Manual.pdf

The following are PE's recommended steps for setting up this logger:

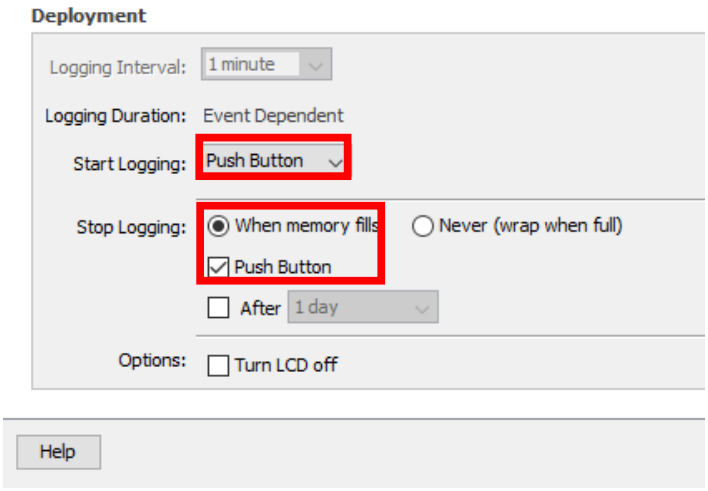
STEP 1 – LAUNCH THE DEVICE (should occur before room placement)

- Connect the sensor to your computer with USB cable and open Hoboware
- You can Download and install HOBOWare by clicking in the following link https://www.onsetcomp.com/products/software/hoboware
- Click the Launch icon on the HOBOware toolbar

- In the Configure Sensors to Log, make sure that Light and Occupancy are set to State. In the "% or Time" Column, make sure Light is set to "off/on" and Occupancy is set to "unoccupied/occupied"



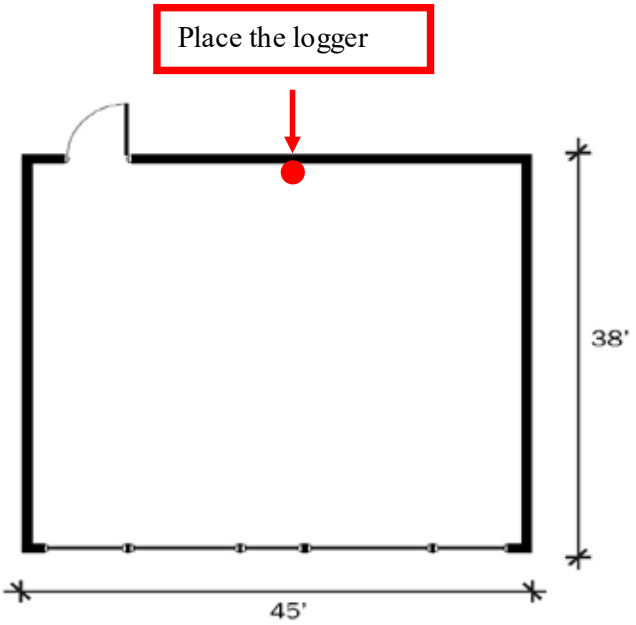
- For Start Logging, Select the “On Date/Time” option, and select the time that you plan to start the study the following day. For Stop Logging, make sure “When memory fills” and “Push Button” are selected.



- Launch the logger by clicking on the Delayed Start option at the bottom right.

STEP 2 – PLACE THE DEVICE

- The logger will be placed in a cafeteria and has a detection area of 45’ X 38’. Make sure you place the logger approximately in the middle of the longer side of the room (as shown in the image below).
- Make sure to place the logger in a place where it is out of reach of (approximately 8’-9’ above floor level). Consider using a ladder or a chair to place the logger on the wall.
- The sensor has 4 magnets on the back that can easily attach to any metallic surface. If there is no metallic surface you can attach the sensor to, please use a command tab to mount the device to an appropriate surface.



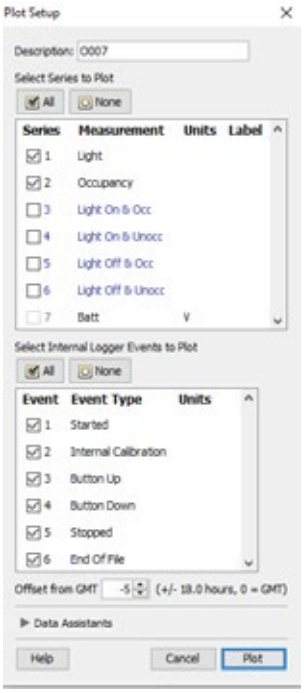
STEP 3 – STOP THE DEVICE

- At the moment of picking up the sensor, press and hold the Stop logging button at the top left of the device for 3 seconds. A STOP sign will appear in the screen of the device, which means data is not being recorded anymore.

STEP 4 – DOWNLOADING THE DATA

- Connect the sensor to your computer with USB cable and open Hoboware. Click on the Readout button.

- Locally save the HOBO file to continue.
- A Plot Setup screen will appear. Make sure the two data points are properly identified – Light and Occupancy. At the bottom of the screen, select Plot.
- The data will then plot out onto the screen.
- Select File > Export Table Data, and click Export.
- Save this data file with the following criteria: **Occupancy _SCHOOL NAME_Cafeteria.csv**, and store it in the project folder.



Occupancy – Tracked by Teacher

At the beginning of each week, please give an occupancy tracker worksheet to each teacher (of the 4 classrooms studied) and ask them to track when the classroom was in use throughout the 4-day study period and when it wasn't.

At the end of the 4-day collection period, make sure to collect this completed occupancy sheet from the teacher.

Scan these sheets and rename the files with the following criteria: **Occupany_SCHOOL NAME_ROOM NUMBER.pdf,** and store it in the project folder.

Illuminance – Extech EA33

A complete user manual can be found here: https://flir.netx.net/file/asset/49036/original
The following are PE's recommended steps for using this tool:

STEP 1: SETTING UP THE STUDY

- Measurements should be taken in all of the studied rooms twice – once in the morning (between 10-11AM) and once in the afternoon (between 1-2 PM).
- Measurements should be taken on a grid throughout the classroom every 5', as shown below.

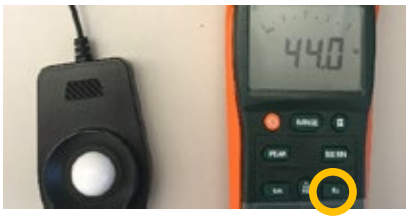
- Identify your rooms in the floorplans, and make sure to note the room number, draw important features like windows and door locations, and note what time you are conducting the measurements and the current outdoor daylight conditions (Cloudy, Partly Cloudy, Sunny)
- 5' can be measured "roughly" using your feet or using guides such as floor or ceiling tiles.
- For the first round, please open all blinds, turn off all lights, and shut doors into the hallway to avoid capturing electric lighting – we are trying to solely capture the daylight conditions. If there is emergency lighting that cannot be turned off that is interfering with measurements, make a note of it on your plan. For the second round, keep all blinds open and doors closed, but turn on

electric lights and reconduct the measurements to study the impact of both daylight + electric lighting on the space.

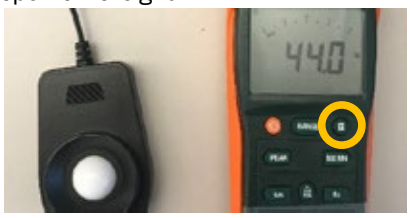
STEP 2: CAPTURING THE DATA

- Turn on light meter using the orange button and remove the black cover from the sensor.

- Confirm that the units on the device are being measured in FC (footcandles) instead of LUX by pressing the bottom right button.



- Measurements will be taken from the white bulb on the sensor, and should be taken at roughly desk height. Please bend down at each measurement to make sure that you are not casting a shadow on the light sensor.
- Hold the light sensor over your head, flat with the sensor facing the ceiling. Make sure your fingers are not blocking the light sensor as you hold it.
- Once bent down and holding the sensor in the proper location, press the H button at the top right to hold the measurement reading. Record this number on your gridded plan and move on to the next point in the grid.

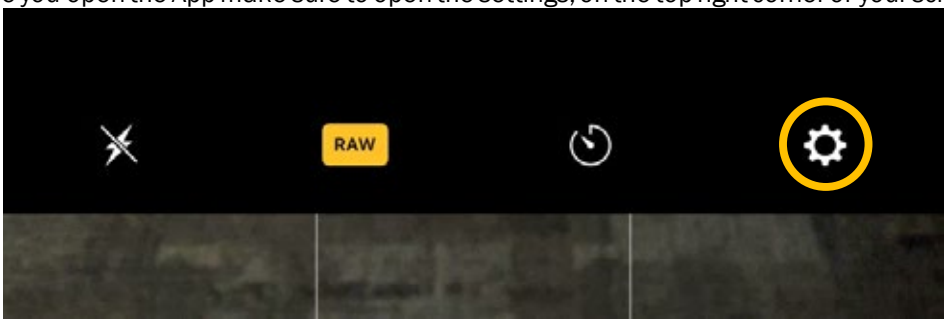


- Press the "H" button again to return to live measurements.
- Scan these sheets, and rename the files with the following criteria: **Daylight_SCHOOL NAME_ROOM NUMBER_morning/afternoon.pdf**, and store it in the project folder.

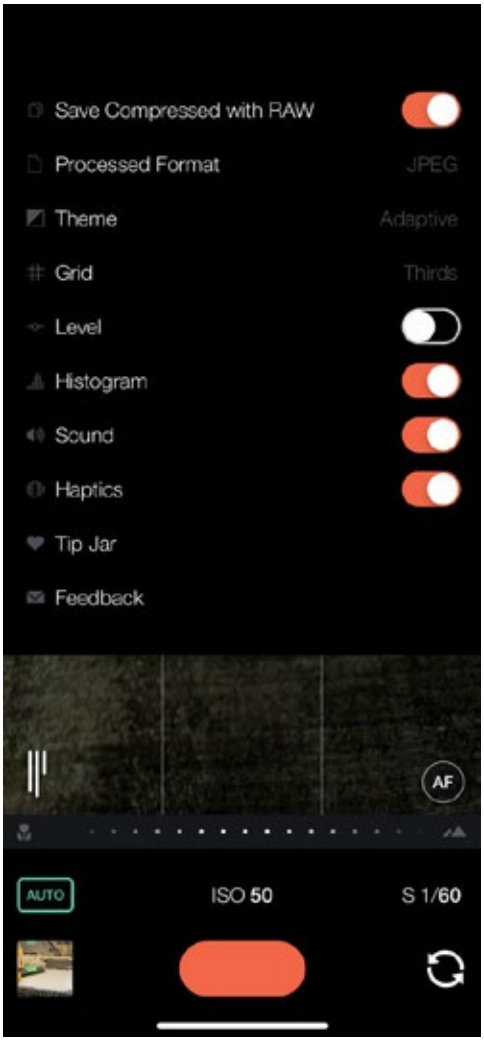
Glare – Camera

FOR IPHONES:

- Open the Manual App (https://itunes.apple.com/us/app/manual-raw-custom-exposure-camera/id917146276?mt=8) or just search for "Manual Raw Camera" in the app store, and download the first option that shows up.
- Once you open the App make sure to open the settings, on the top right corner of your screen



- Under Settings at the top right, make sure that the "Save Compressed with RAW" button is on.
- Select JPEG as your Processed Format
- Select Thirds as your Grid Option
- Turn Off Level
- Make sure Histogram, Sound, and Haptics are ON
- At the bottom left of the screen, ensure that the camera is in Manual Mode by clicking the "AUTO" button until the rectangle is no longer colored.
- At the bottom mid of the screen, Alter the ISO to 58, by swiping up or down.
- At the bottom right of the screen, Alter the Shutter Speed (S) to 1/60.
- At the top left of the screen, ensure that the camera is in Raw Mode by clicking the "RAW" button until the rectangle is no longer colored.
- Please leave these settings consistent for EVERY space that you photograph.
- For the first photos, please turn off all lights and shut doors into the hallway to avoid capturing electric lighting and solely capture daylight conditions.
- Once all the settings are in place, stand in the middle of the classroom and face an outside corner of the classroom, with the corner in the center of the shot, as shown in the image below. Rotate to the other outside corner, and take a second photo.
- Then, turn on the lights and repeat.
- Please keep track of which photos were taken in which classrooms in which school!



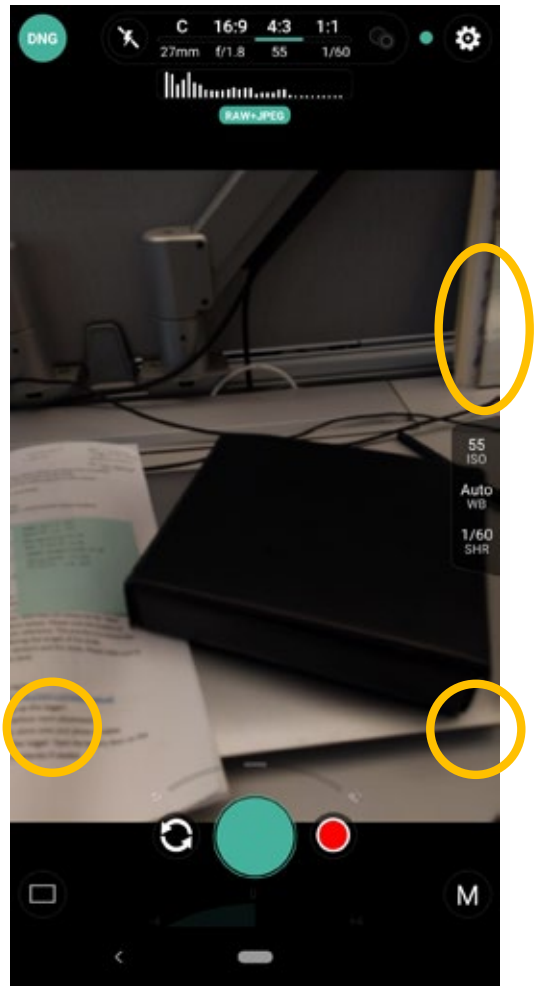
- Send these photos to your e-mail, and rename the images as **Glare_SCHOOL NAME_ROOM NUMBER_morning/afternoon_R/L**, and store it in the project folder.

FOR ANDROIDS:

- Open the ProShot App (https://play.google.com/store/apps/details?id=com.riseupgames.proshot2&hl=en_US)
- Once you open the App, open the settings on the top right corner of your screen

- Tap JPEG at the upper right until it says RAW+JPEG
- Keep the other settings as shown above

- Touch the screen to return to the main view
- Make sure the bottom left of the screen shows a rectangle – meaning it is in Normal mode
- Make sure the bottom right of the screen shows an M – meaning it is in Manual mode.
- Set ISO to 55, Maintain Auto for WB, and Select 1/60 for Shutter Speed
- Images will be stored under you Photos as both a RAW file and a JPEG. Please save both to the folder
- Please leave these settings consistent for EVERY space that you photograph.
- For the first photos, please turn off all lights and shut doors into the hallway to avoid capturing electric lighting and solely capture daylight conditions.
- Once all the settings are in place, stand in the middle of the classroom and face an outside corner of the classroom, with the corner in the center of the shot, as shown in the image above, in the iPhone section. Make sure to take the photo in landscape instead of in portrait. Rotate to the other outside corner, and take a second photo.
- Then, turn on the lights and repeat.
- Please keep track of which photos were taken in which classrooms in which school!
- Send these photos to your e-mail, and rename the images as **Glare_SCHOOL NAME_ROOM NUMBER_morning/afternoon_R/L**, and store it in the project folder.



Sensor Location Selection

To select the spaces that were sampled in each school, the researchers used the following procedure:

- First, to represent typical learning environments, the researchers identified all the classrooms within a school dedicated to core-learning. Spaces like science labs, art rooms, and small group areas were excluded in order to focus on the typical core-learning environments.
- To determine the number of classrooms to be studied in each school, the researchers aggregated the total number of core-learning spaces found in all the modernized schools vs. all the non-modernized schools, and targeted a 95% confidence level and 10% margin of error. From this assessment, the researchers determined that four classrooms in each school would be studied.
- The floor plans of each school were then evaluated to identify the core-learning classrooms, which were then further broken down by cardinal orientation (N/S/E/W) and by floor level. The percentage of rooms facing each orientation, and on each floor, determined how the selected four rooms would be distributed within that school. Then, the most centrally located typical classroom for each orientation/floor was identified. Once the classrooms were identified based on the floor plans, they then were confirmed with the school to ensure: the rooms were utilized; they were used for core learning; the rooms' teachers would be amenable to participating in the study; and the classrooms would be regularly occupied during the study period. For any classroom that did not conform to these criteria, an alternate classroom was selected that did meet these requirements.
- In addition to four classrooms per school, the researchers decided to also study a communal/shared space in each school. The researchers identified the cafeteria as the communal space to study in each school as it was a space that could be found and would remain relatively consistent across each school in the sample. A common space was selected because, at some point in the day, everyone in the school would have access to it, and it may have a higher risk of poor performance due to its size, ability to be maintained, occupancy, etc.

Occupancy Tracker

LATROBE RESEARCH STUDY **SCHOOL_____ ROOM #_____**

Thank you for participating in this study! To help with data collection, we need to know a little bit more about how your classroom is used this week. To help us out, on the following chart please block out the times when your classroom is occupied this week, and note roughly how many people are in the room during those times.

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
7:00 AM					
8:00 AM					
9:00 AM					
10:00 AM					
11:00 AM					
12:00 PM					
1:00 PM					
2:00 PM					
3:00 PM					
4:00 PM					
5:00 PM					
6:00 PM					

Sample Data Summary

THERMAL COMFORT	
Average % of time OUTSIDE the comfort zone	72%
Average temperature swings (°F)	7.5
Lowest temperature (°F)	64.7
Highest temperature (°F)	80.4
AIR QUALITY	
Average CO2 levels (ppm)	779.6
Lowest CO2 reading (ppm)	401
Highest CO2 reading (ppm)	1669
ACOUSTICS	
Average Ambient Noise level (dB)	38.8
Average Occupied Noise level (dB)	48.1
Highest Occupied Noise level (dB)	87.8
DAYLIGHT	
Average %age Overlit Floor Area - Daylight only	0%
Average %age Underlit Floor Area - Daylight Only	98%
Average %age Overlit Floor Area - Electric + Daylight	0%
Average %age Underlit Floor Area - Electric + Daylight	25%

CONTACT US

We welcome further inquiry about the study and how to apply the findings to the modernization of schools.

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