SESSION TITLE

Building a CO_2 Sensor

ACTIVITY IN A SENTENCE:

Assemble a CO_2 sensor and understand why the measure of CO_2 is important on a local and global scale.

DISCIPLINES INVOLVED IN ACTIVITIES:

Physics, Biology, Environmental Science

RECOMMENDED AGES:

14+

LEARNING ENVIRONMENT (CONTEXT SETTING):

Makerspace, class, outdoor, university

LEARNING OUTCOMES:

- Learn about basic electronic circuits
- Collect and interpret data (understand variables, draw graphs)
- Understand the role CO_2 plays in human physiology and climate change

The topic was chosen by teachers and learners during a session about the most concerning issues on both local and global scales. Climate change and the pandemic scored the highest among the learners of our group. It was then decided to build CO_2 sensors to be distributed in the classrooms to know when to aerate, and to measure the emission of CO_2 in different contexts. In parallel, university researchers were invited to present their research related to CO_2 in climate change. A local company awarded the learners water bottles that were produced during an awareness campaign about climate change. Finally, the project and results were presented to the general public at the Natural History Museum of Geneva.

RECOMMENDED EXPERTISE:

Basic electronics and soldering

SDG LINKS:

- **Goal 3:** Ensure healthy lives and promote well-being for all at all ages
- **Goal 4:** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- **Goal 13:** Take urgent action to combat climate change and its impacts

TIME IT TAKES TO COMPLETE:

- Co-creation session: 1.5 – 2 hours
- Assembling: 1.5 – 7.5 hours based on the level of explanation of different components and use of machines for the sensor case (plastic and wood)
- Installing the sensors and measuring: 2 – 4 hours
- Interpretation of the data: 2 hours
- Session with the experts: 1.5 – 2 hours x 2
- Preparation of the mini-expo: 2-6 hours
- Mini-expo: 6 hours
- Evaluation: 2 – 4 hours

MATERIALS / RESOURCES NEEDED:

- CO_2 sensor MH-Z19B
- Microcontroller Arduino Nano (with USB cable)
- Light Emitting Diode (LED) display 7 segments TM1637
- 12 jumper cables female-female
- Heat shrink tubes
- 40g PLA for 3D printing
- 3 LED (red, green, yellow)
- 50x50x3mm plywood
- 3D printer
- Laser cutter
- Computer
- Soldering irons

CONTENT FOR LEARNERS:

Wiki converts the instructions into a *printable PDF* [French]

TIPS FOR SCALING FOR DIFFERENT AUDIENCES:

The activity can be adapted to younger audiences by not explaining the function of each component and avoiding the analysis of the data.

The activity can be adapted to learners of electronics or informatics by programming the Arduino to show messages on the display based on the "live" measurements.

Activity

Introduction: Co-creation

- Start the activity with a presentation about Open Schooling. Use examples of local issues that are tackled with smart solutions developed by the youth and citizens. Show examples of technology for sustainability.
- Divide the class in smaller groups and distribute cards with a list of issues (traffic, climate change, etc). Ask the group to rank them from the most concerning to the least and to add one more issue specific to their community. Let the learners justify their choice and find a consensus to select the topic to work on.
- Once the topic has been chosen, you can decide to propose an idea (more or less defined) or facilitate a second session to come up with a technological solution.

(In our case the chosen topics were Covid-19 and climate change and we proposed to build CO_2 sensors)

Part 1: Assembling

Below is a step-by-step guide on how to assemble the CO_2 sensors. More photos and detailed instructions are available in the link below, however instructions are in French. *(Drawing files and instructions (in French))*

1. **Make the box.** To mount the sensor, you will need to download and then print the 3 elements of the box. One face has to be laser cut and the box 3D printed. See 'Step 2' in the linked instruction manual for 3D printing files [French].

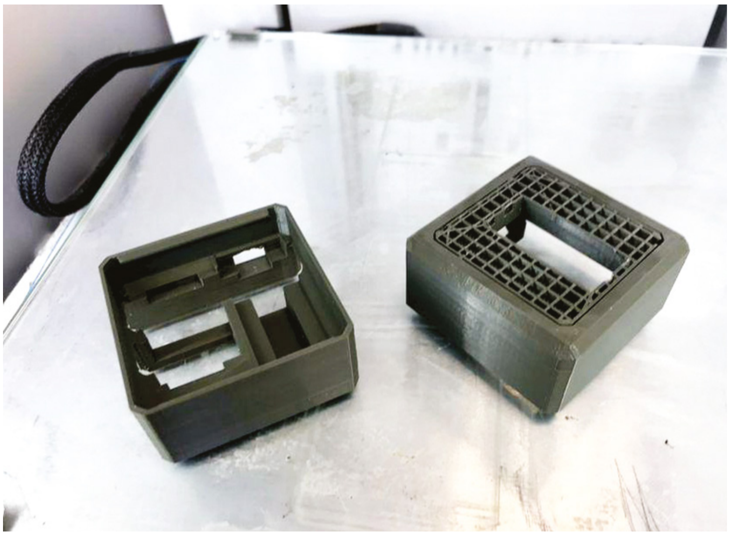

Figure 5.13: 3D printed sensor box. Credit: FAB.

2. **Place the electronics in the box.**
3. **Wiring.** Since the Arduino has a 5V output, you will need to prepare Y wires, with female-female jumper cables wire to power both components. Solder the wires and protect them with heat shrink tubes.

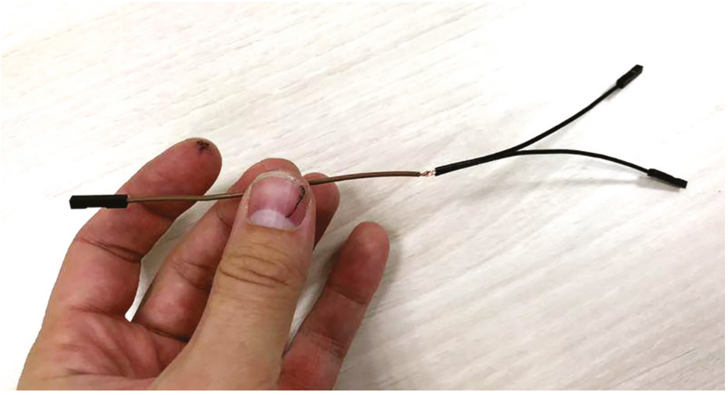

Figure 5.14: Prepared Y wires. Credit: FAB.

4. **Mounting the LED.** Solder the 3 cathodes of the LEDs and solder a 680 Ohm resistor to the anode.

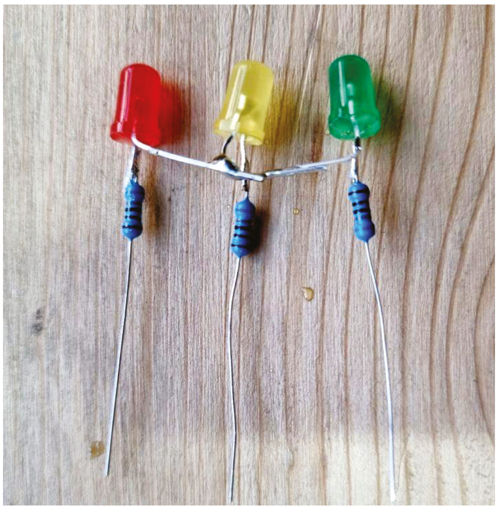

Figure 5.15: Soldered LEDs and Ohm resistors. Credit: FAB.

5. **Make the connections.** Follow the plan to connect Pins:

- Pin D11 (Arduino) > Pin RX (CO_2 sensor)
- Pin D10 (Arduino) > Pin TX (CO_2 sensor)
- Pin D4 (Arduino) > Pin CLK (7 sec display)
- Pin D5 (Arduino) > Pin DIO (7 sec display)
- Pin D6 (Arduino) > + side of the red LED
- Pin D7 (Arduino) > + side of the yellow LED
- Pin D8 (Arduino) > + side of green LED
- Pin 5v (Arduino) > Pin V+ (CO_2 sensor), Pin Vcc (7 sec display)
- Pin GND (Arduino) > Pin V – (CO_2 sensor), Pin Gnd (7 sec display)

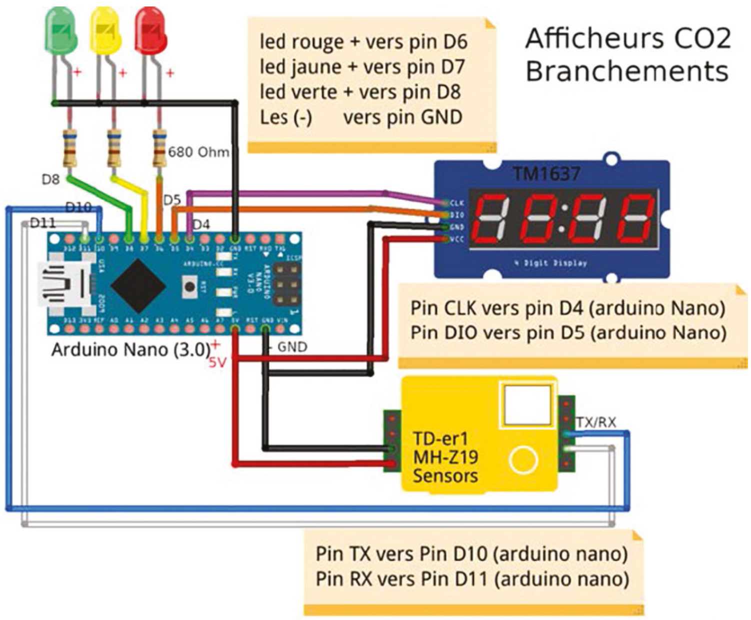

Figure 5.16: Overview of connections [French]. Credit: FAB.

6. Close the box.

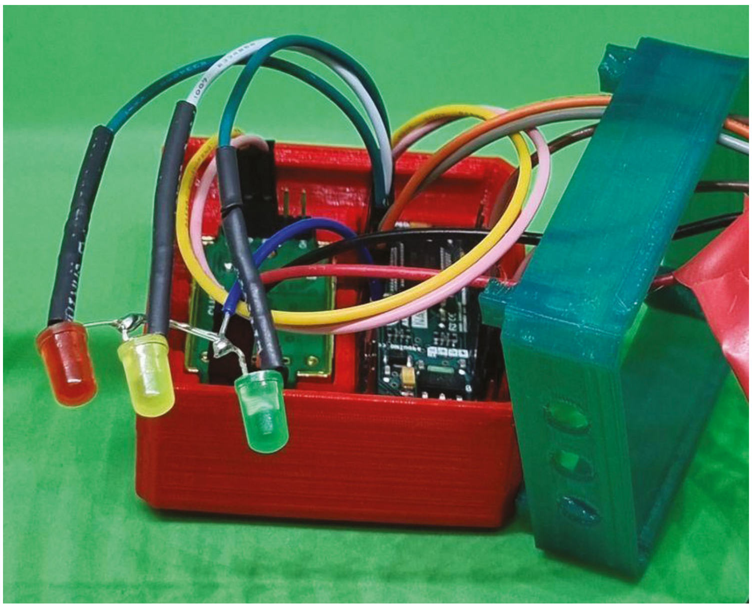

Figure 5.17: Inside the box before closure. Credit: FAB.

7. Download the Arduino code. Connect the sensor to your computer with a USB cable. Copy the code made available in the documentation then, with the Arduino software, upload it to the Arduino Nano. Once uploaded, the sensor should work properly and display the live CO_2 level on the display.

Figure 5.18: Finalised sensor showing CO_2 level. Credit: FAB.

8. **Save measurements to a csv file.** When the box is connected to a PC, the python script datalogger.py allows you to save the readings in a log_CO2.csv file which will contain the time and the CO_2 level in PPM. You can then open it in a spreadsheet to view and analyse the results. Remember to modify the script to adapt it to the serial port to read the data (for example ‚/dev/ttyUSB0' for Linux and ‚COM0' for Windows).

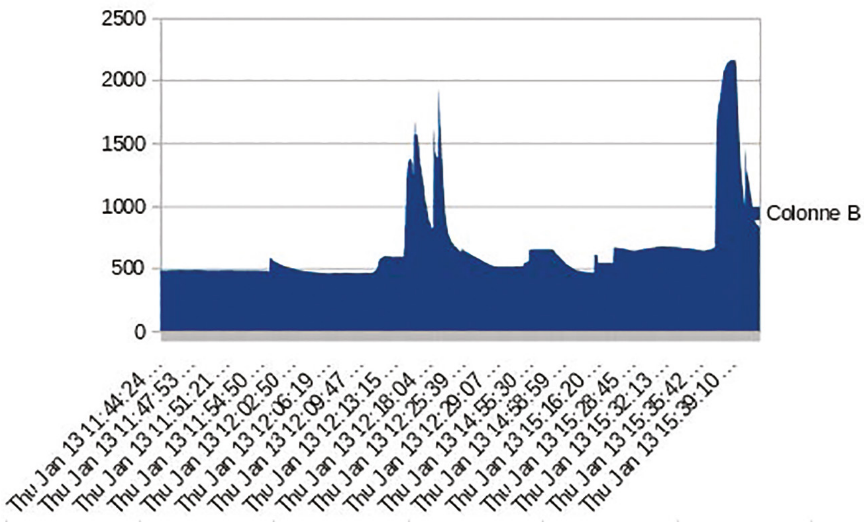

Figure 5.19: CO_2 level measurements taken from sensor. Credit: FAB.

Part 2: Measuring

Install the sensors and take measurements in different conditions to compare results.

Examples: indoor, outdoor, before and after opening a window, next to a flame, close to the mouth, etc.

Part 3: Researchers

Invite researchers and experts to present the scientific research related to the chosen topic (such as a researcher in climate change, or a doctor, nurse or expert in health issues. They can be invited at the beginning of the project (to help set the scientific objectives), in the middle (to advise and exchange) or at the end (to allow learners to first master the topic so they can ask meaningful questions)

Part 4: Presentation

Prepare posters and an interactive stand to present the project to the other school learners or to the general public. It's important to show the whole process, not only the sensor.

Part 5: Evaluation

Use the zines at the beginning and during the project to help learners reflect on the bigger picture related to the measurement of CO_2 .

Credits: The sensor was designed by Tony Vanpoucke l'Edulab – Université Rennes 2, and modified for this activity by Onl'Fait Makerspace, OSHub Switzerland.