Making Scientific Data and Learning Playful & Tangible

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Computational crafts
in Citizen & Community Science

Collect. Compute. Make. Share.

Despite efforts to diversify science, women and people of color remain underrepresented in science, including community & citizen science (CCS). We believe this is in part due to the narrow nature of practices, values and stories legitimized within science and science education. Within larger efforts to broaden participation, it is important to support playful, expressive and tangible work in CCS.

With these open-source tools and resources, learners engage with CCS data and concepts as they create expressive, interactive objects. Allowing people to play - to envision new ways of acting and interacting with science - these tools offer new entry points and pathways in CCS, and can foster a sense of connection, hope and personal action.

Paper Mechatronics and *Luminous Science* are designed for learners and educators. Using them, craft and computation can accompany collection of CCS data.

Join us! Contact us if you are interested in project updates, resources, and research opportunities. cdixon@concord.org

Quantitative data is translated into light or movement and built into dynamic, expressive sculptures that can be shared across settings and audiences. In addition to the examples here, many kinds of sensors could be used and we are currently working on a tool that would allow use of static datasets and live online data.

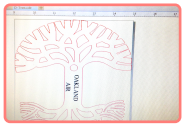
CCS pilot workshop
environmental justice + mobile makerspace

To test these ideas with middle and high school students, the BetaLab mobile workshop and non-profit East Bay Academy for Young Scientists, collaborated with an environmental justice organization to collect air quality data in the transit system and neighborhoods impacted by truck traffic. Using open-source sensors, electronics and digital design software, the young people designed devices that made air quality data visible in real-time. They identified target audiences and strategies relevant to their own lives and communities, then designed and prototyped using a laser cutter and Arduino microcontroller.

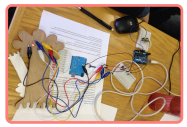
Over the course of five sessions, the workshop used "making" activities as a way to exercise problem solving, deepen connections to the scientific work, and give youth a way to advocate for change. In one example, a young woman, Aynalem, created a "bookmark" with LEDs that represented her city and reflected the level of fine particulate matter. Creating the bookmark allowed Aynalem to (1) share data with people who read on the subway, something she liked to do, and (2) work in CCS in a way that helped her take the lead within the project and display interests and expertise to friends and family

1 AirBeam open source air quality sensor to gather PM data

2 I/O board (no longer produced) to translate from sensor to serial



3 Aynalem designing her "bookmark" for the laser cutter



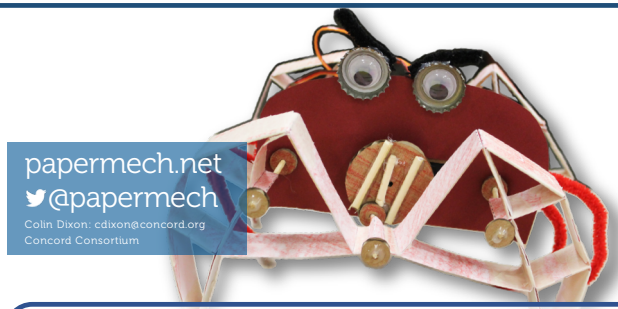
4 Prototyping circuits, interaction, design in paper and wood

5 Aynalem's tree displays PM level by light color

6 Deploying sensor and display devices in the transit system

1. Dixon, C., Martin, L., Grzesik, D., & Cuff, K. Making Visible Environmental Risk and Scientific Research. FabLearn 2016. Stanford, Ca.

Pilot research conducted through a collaboration between BetaLab (UC Davis School of Education), East Bay Academy for Young Scientists (UC Berkeley Lawrence Hall of Science) and West Oakland Environmental Indicators Project, with support from the National Science Foundation, Grant No. EEC-1351605.



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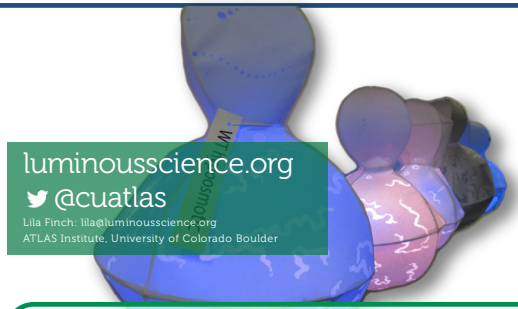

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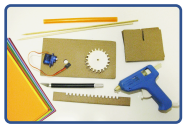
Paper Mechatronics
telling stories with data, paper, and movement

Data: **fine particulate matter (PM2.5).** Temp, light, C02 – any sensor with serial output can be used.
Display: **coughing frog** (pm level)

Movement is powerful for telling stories about places and data. Familiar, low-cost materials allow learners to tinker, play, and bring citizen science home.

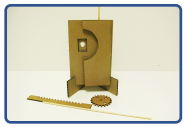
Paper Mechatronics tools and resources allow young people to visualize and share data in new ways. Developed by the Concord Consortium and designer HyunJoo Oh, Paper Mechatronics allows learners to design moving sculptures, using gears and linkages made from paper and cardboard that can be powered by servo motors. These can be controlled with a range of microcontrollers, from Arduinos to low-cost DIY cardboard circuits. Learners can write programs that process data streams from sensors or online and translate them into mechanical action.

- Sharable – objects help young people make their research (and expertise) visible across settings.
- Low-cost, familiar materials – broaden accessibility and make room in CCS for a range of interests, strengths, and experiences.
- Expressive – new ways for young people bring and build stories, ideas, and identities in science.

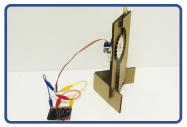


. Craft supplies for Paper Mechatronics

1 Design a mechanism. Think about your data, audience & goals



2 Cut cardboard (by hand or laser) and build the mechanism



3 Test movement with a servo and microcontroller

4 Build the rest of the machine to tell your story

5 Program the servo to interact with your data. Then share!

This paper frog displays level of fine particulate matter (PM) in the air. As PM 2.5 level goes up, the frog closes his mouth and coughs.

Luminous Science
science-art-computation

Data: **moisture, humidity,** and **transpiration.** Temp, light, C02 also possible.
Display: **speed of rotating lights** (humidity); **bar graph of light** (moisture).

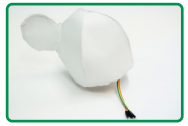
Students analyze data and explore scientific concepts as they visualize data through dynamic light sculptures.

With *Luminous Science*, developed by Lila Finch and the Laboratory for Playful Computation, students build hydroponic gardens and collect data from sensors, microscopes, and others measurements. Using crafting techniques of Nebuta, a form of Japanese lantern making, alongside electronics and computational technologies, learners work across disciplines to bring data to light.

. Craft supplies for the paper lantern

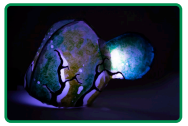
1 Create a frame with wire and string dipped in glue

2 Position LED strips and jumper wires. Fasten in place.



3 Cover the frame with paper, folding over at the seams.

4 Paint the paper with colors and wax.

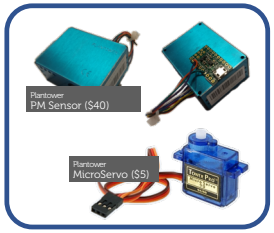


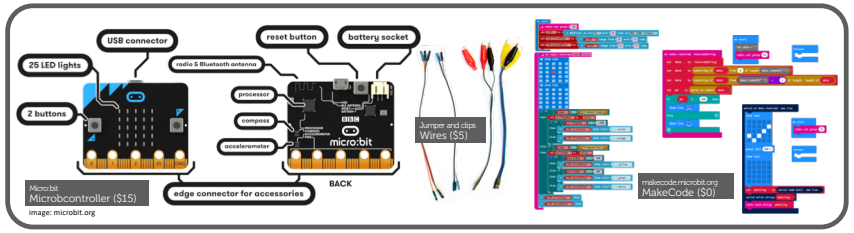
5 Program the LEDS (see below) and connect to sensor.

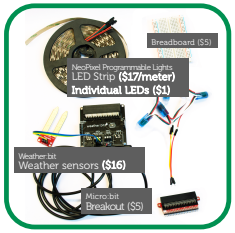
In this sculpture, two sets of dynamic lights show if transpiration is occurring or not due to low moisture or high humidity in a hydroponic garden.

Hardware & Software

To make either of these examples in your CCS project, you can use Micro:bit, a microcontroller designed for education. Other microcontrollers can also be used, such as the Arduino and Hummingbird boards, depending on what kind of data you have and where you want learners to focus attention. Micro:bit has built-in temperature, light, and movement sensors. With add-ons like the Weather:bit, or external sensors, like PM or CO2 sensors, other kinds of data can be used. 1 Set-up one Micro:bit to get data from a sensor. 2 Use MakeCode, a "block" programming language, to program this board to process and send out data via radio. 3 Design your project, thinking about stories and audiences you want to connect with. 4 Use wires and breadboard to connect one or more "receiving" Micro:bits to LEDs, for a customized light display, or servo motors, for mechanical movement. 5 Program the receiving Micro:bits to visualize your data. Each Micro:bit can do something different, allowing students to create unique projects. Participants can copy-paste code and instead focus on design and fabrication, or can use software like MakeCode or Arduino IDE to write and modify code, depending on learning goals and time constraints.







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