Using Arduino-based sensors on nanosatellites to engage middle and high school students with science and coding

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Grand Rapids, MI
March 2, 2019

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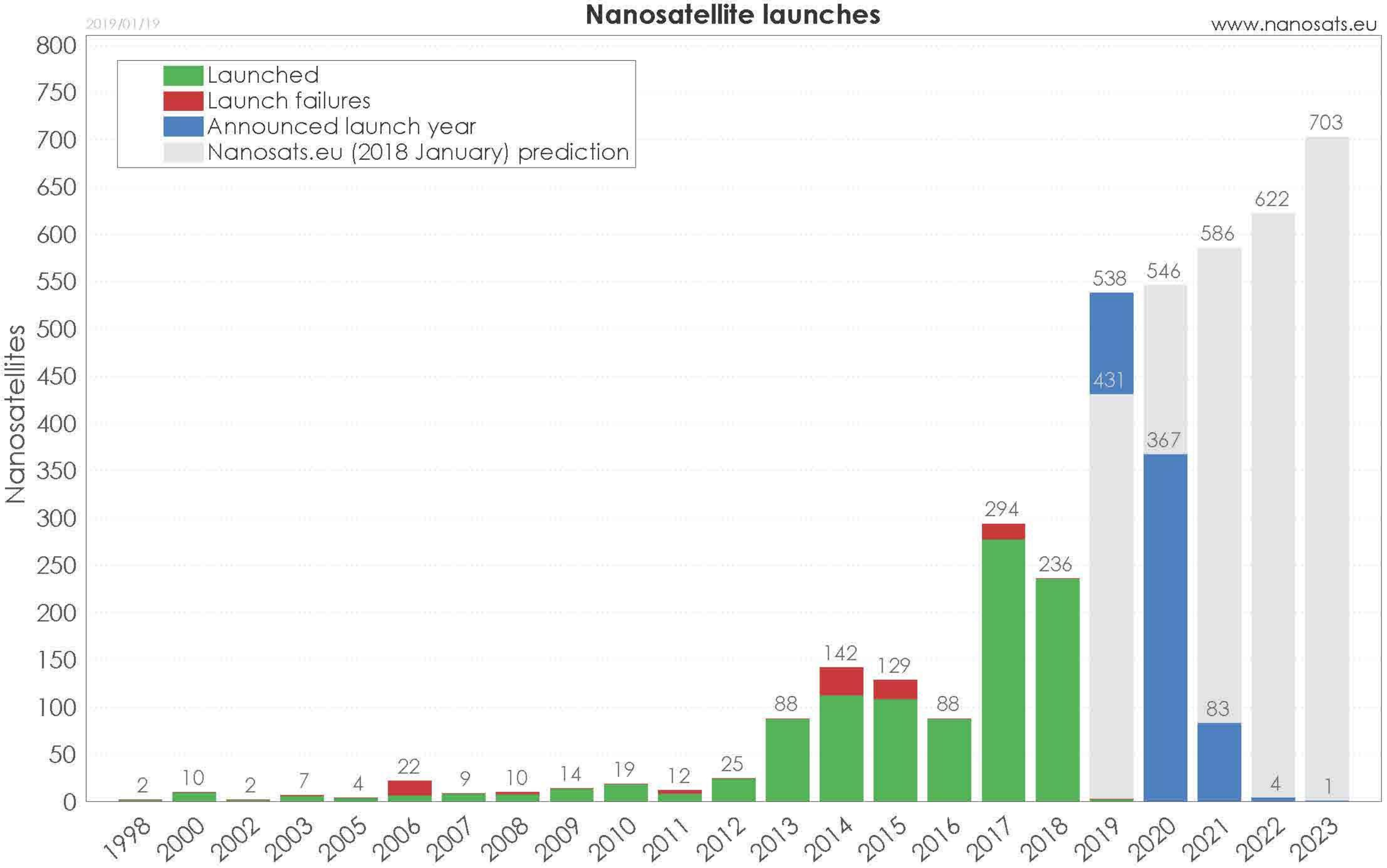
What is a Nanosatellite?
… and what do they do?



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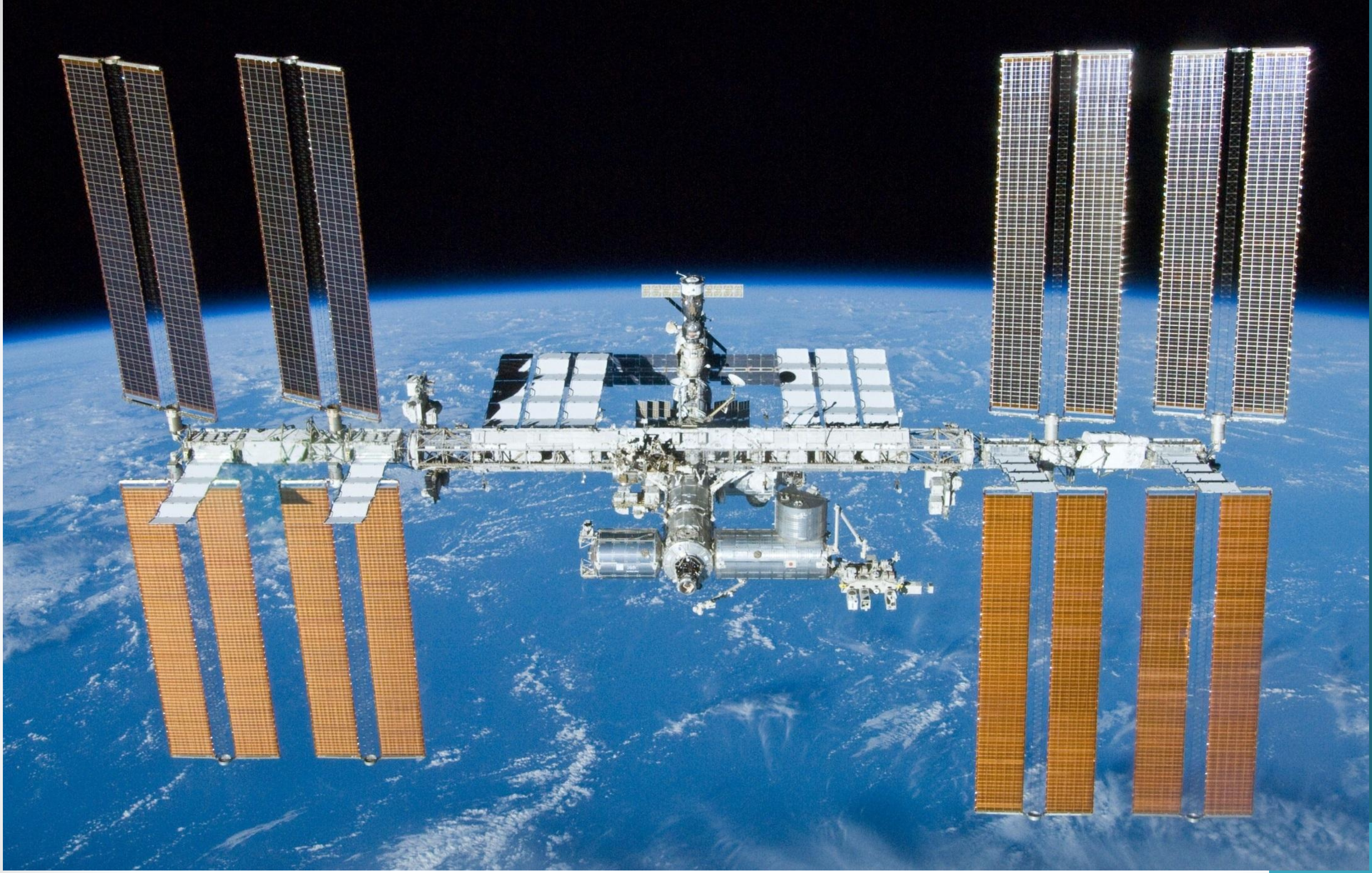

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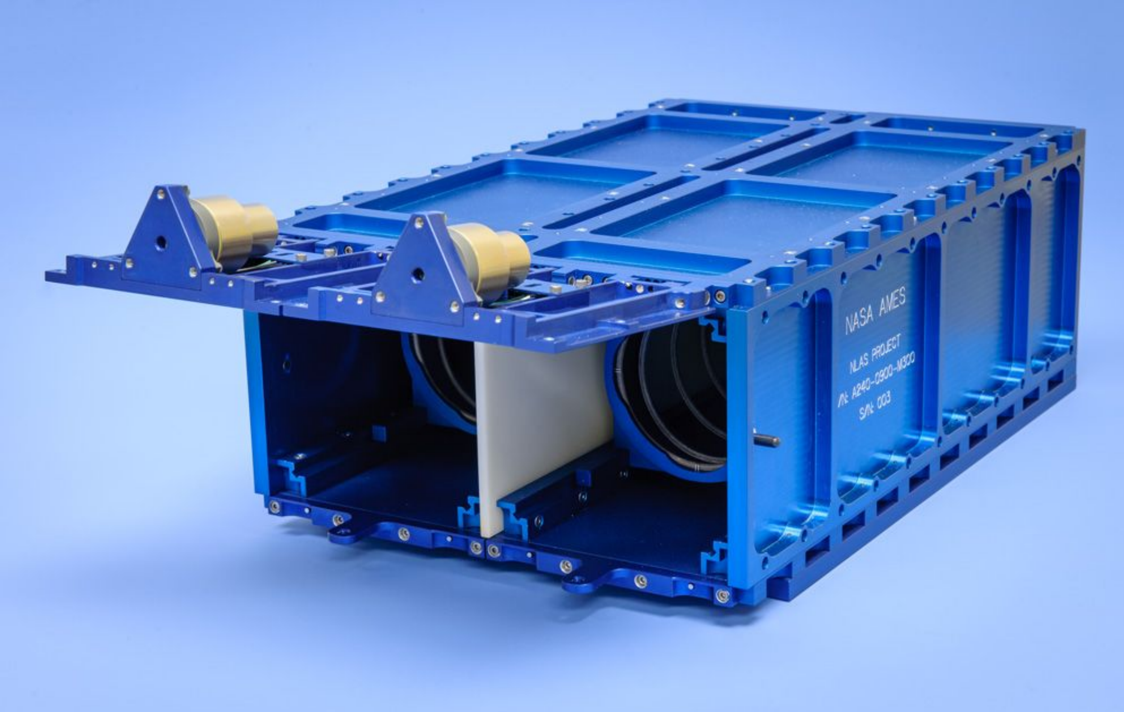

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Project Goals

- **For the Curriculum**
  - Have students conduct scientific investigations using the nanosatellite's sensor board
  - Familiarize students with the sensors:
    - What they measure
    - Their limitations
  - Have students plan an investigation that utilizes the sensor board on an orbiting nanosatellite.

Project Goals

- **For the Curriculum (continued)**
  - *Expose* students to programming and provide opportunities for them to learn more.
  - Interact with STEM professionals
- **For Research**
  - Understanding the design differences for three different implementations:
    - Afterschool (Emeryville High School)
    - Summer camp (Lawrence Hall of Science)
    - In science class (Civicorps)

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Civicorps

DEMOGRAPHICS

57% African/African American

17% Hispanic/Latino

14% Two or more races

8% Asian/Asian American/ Pacific Islander

4% White, American Indian or Alaska Native, and Other

39% Female

<1% Transgender

61% Male

18% Experiencing homelessness*

45% Justice-involved*

30% Have a learning disability

29% Parents of young children

39% Victim of violence*

17% Former foster youth*

*self-reported

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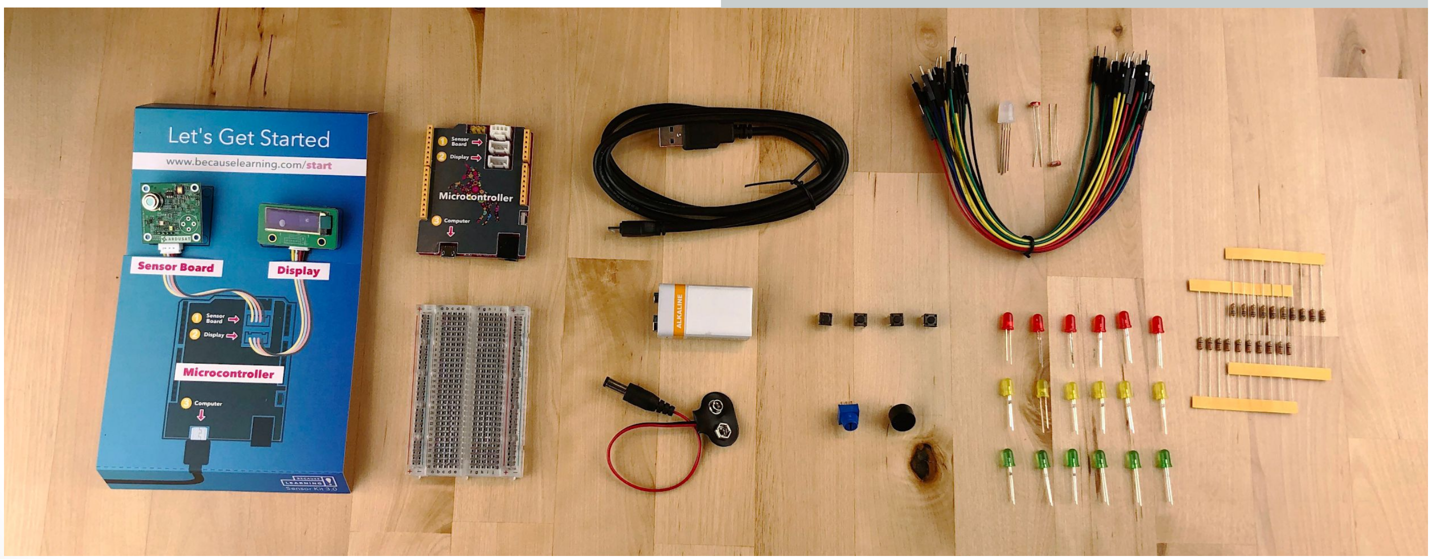
Project Goals

- **For Research (continued)**
  - Understanding how students' values of the learning environment and expectations for success influence their engagement.
- **For Research (moving forward)**
  - What can we learn about designing for equity and inclusion in science learning environments.

Key Materials

- **Because Learning! Launch Kit**
  - Arduino
  - Sensor Board
  - OLED Display

BECAUSE LEARNING!



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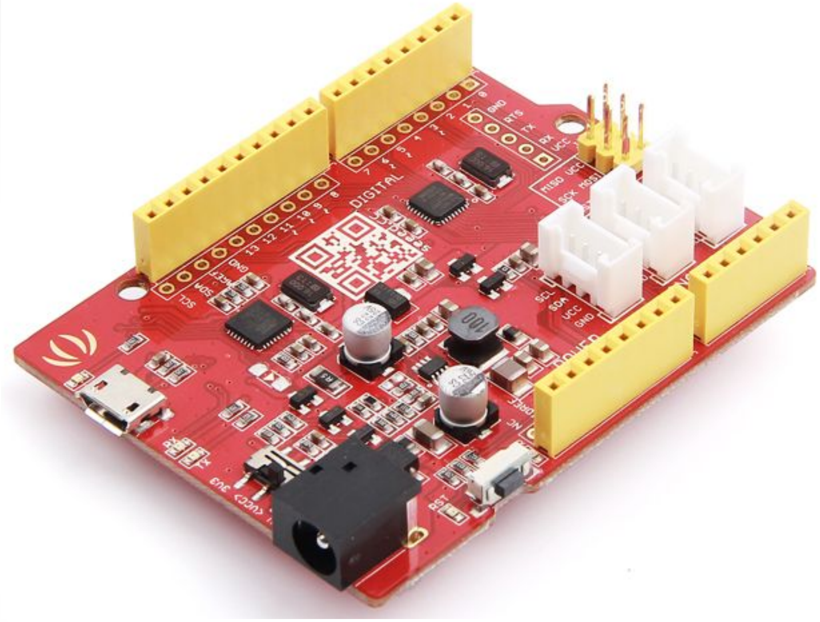
Key Materials

- **We Provided**
  - SD Card writers for Arduino
  - Computers (Chromebooks)
  - Servo-motors
  - Materials for specific experiments:
    - UV Lights
    - Sunglasses
    - Sand/Water
    - Filter gels

Arduino + Sensor Board



Sensor Board

- Sensors:
  - accelerometer
  - magnetometer
  - gyroscope
  - temperature
  - IR
  - luminosity
  - red, green, and blue light
  - UV

What Scientific Investigations could you do in your class with these sensors?

- accelerometer
- magnetometer
- gyroscope
- temperature
- IR
- luminosity
- red, green, and blue light
- UV

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Our Focus

- **Climate Science**
  - Differential Heating of Surfaces
  - UV and IR Radiation from the Sun
- **Physics**
  - Electromagnetic Radiation
  - Satellite Kinematics

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Measuring the Unseen

- **Infrared Sensor**
  - “Zombie Detector”
  - Sand vs. Water Experiment

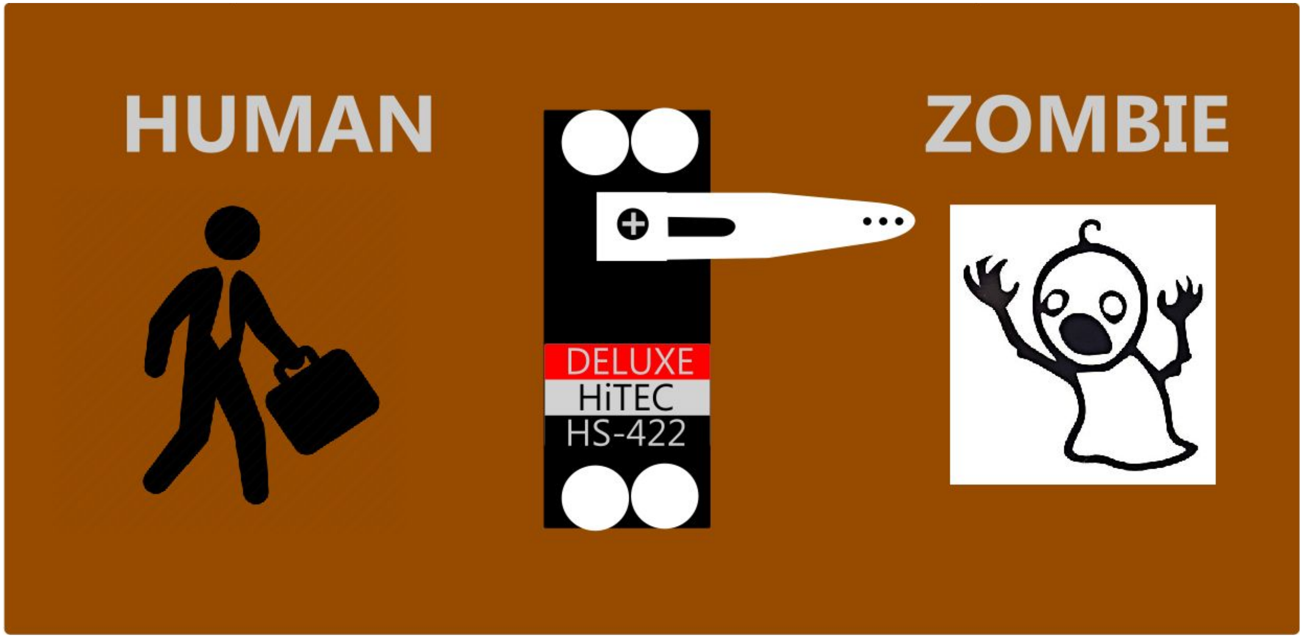
- **UV Sensor**
  - Sunglasses Experiment

- **Combination**
  - Filter gels

Measuring the Unseen

Zombie Detector

- **Determine if a can of soda is at room temperature or colder than room temperature**



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Measuring the Unseen

Sand vs. Water Experiment

- **Measuring the rate at which both materials heat up in the Sun using the IR Sensor**

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Measuring the Unseen

Analog version of the Sand vs. Water Experiment

- **Measuring the rate at which both materials heat up in the Sun using thermometers**

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Measuring the Unseen

Sunglasses Experiment

- **How much UV Radiation does *your* pair of sunglasses block (absorb or reflect)?**

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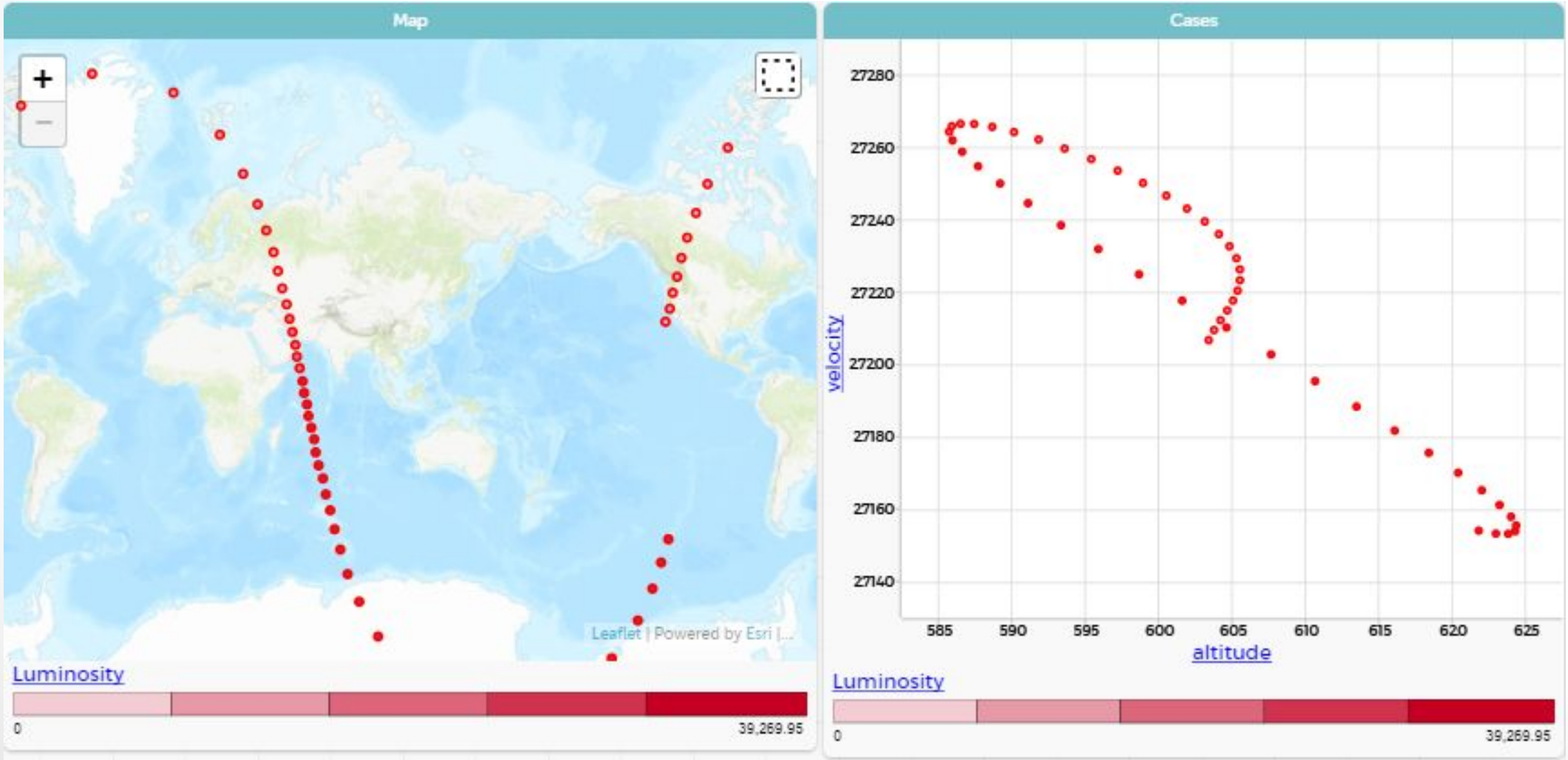
Nanosatellite Investigation

- Student could determine:
  - Rate at which data is captured (ie once everyone minute)
  - Type of orbit
    - Polar
    - Equatorial
    - International Space Station
  - Which sensors are used (there is a data cap)

Analyzing Data

- CODAP (https://codap.concord.org/)



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Student Presentations

Student presentations were an important part of each program.

STEM professionals were present to ask questions.

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Lessons Learned

We found that is was a cognitive burden to ask students to simultaneously:

- use new-to-them tools
- learn, or at least begin to parse, programming languages
- conduct scientific investigations

So, we developed a new component for the curriculum to prime students for the Arduino portion

Nano-Spacestations

What behaviors would you ask students to design into a robotic space station that has:

- lights
- motors
- light sensors
- distance sensors
- and sound sensors?

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Nano-Spacestations

Using Hummingbird Robotics kits, we developed curriculum designed to teach students the basics of programming and sensors through robotics.

This worked really well because:

- **The programming language was easier (the "Scratch" block-based language)**
- **Robots give physical responses rather than numerical data**
- **Students didn't need to conduct data analysis/interpretation**

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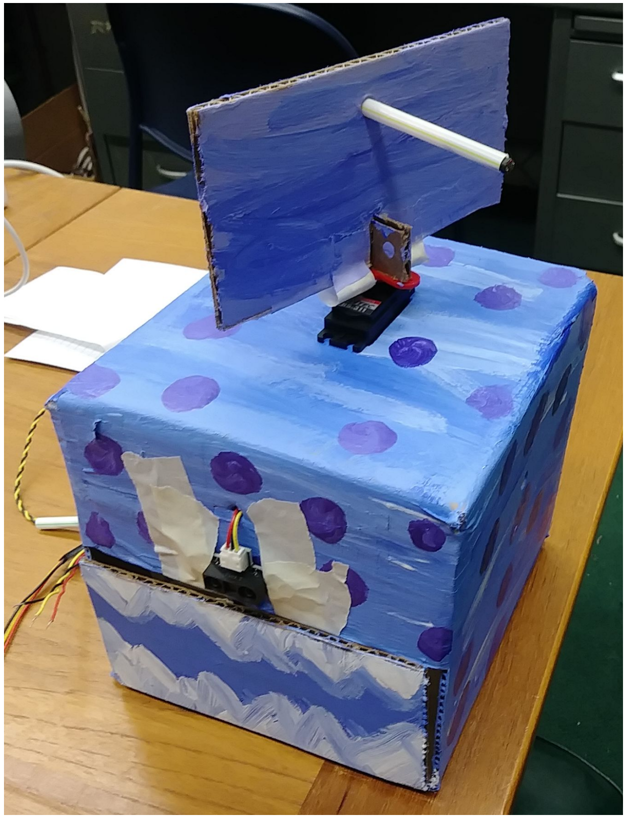
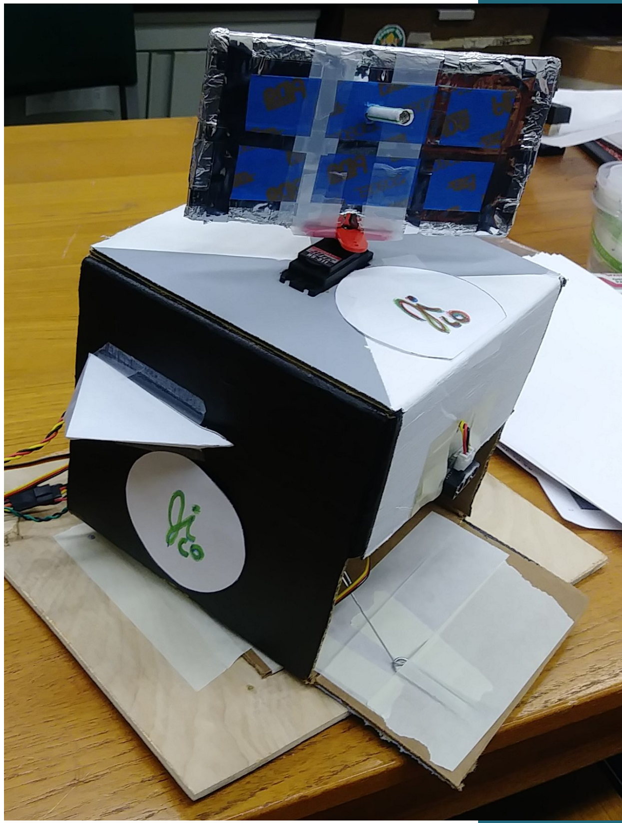
Nano-Spacestations





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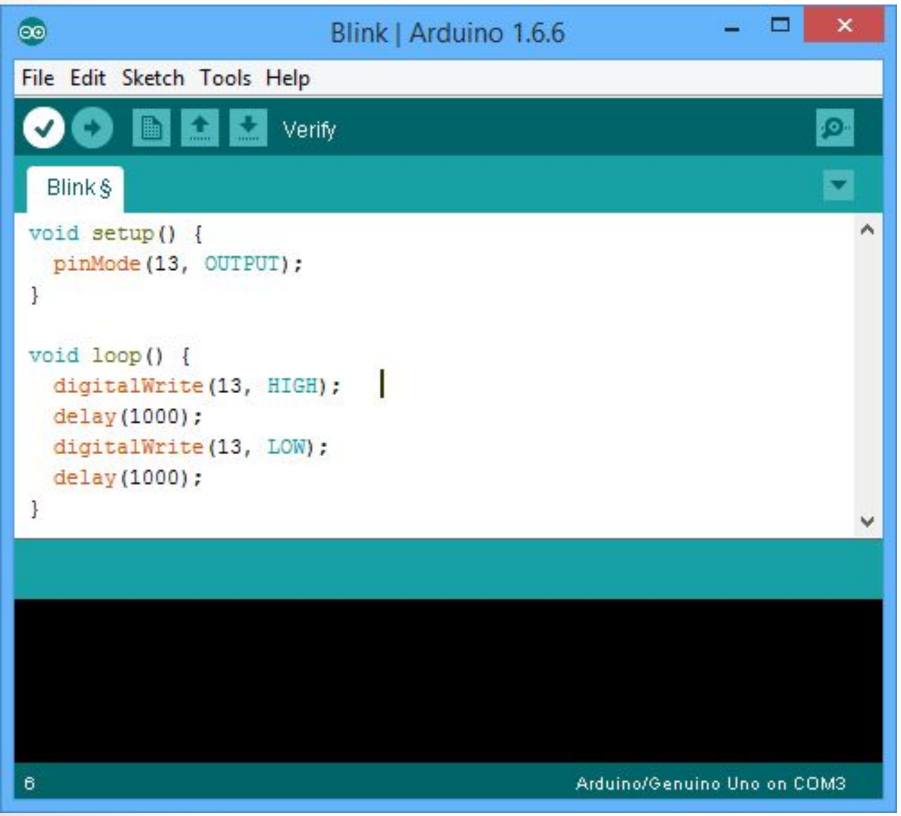
Lower Entry Point

Arduino

Text-based language



Vs.

Scratch

Block-based language

Set up for Success

By leading with the Robotics and block programming portion:

- **Students were more comfortable with the idea of algorithms and the relationship between code and input/output devices**

- **More confident in their ability to understand the text-based Arduino programming language later on in the curriculum**

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Notable Takeaways

- **Troubleshooting Technology requires scientific thinking**
- **Simply *exposing* students to programming languages made them less weary/intimidated**
- **Students know how to figure out technologies even if instructors don't**
- **Arduino (text-based) programming language isn't very friendly for first time programmers but Scratch (block-based) is.**
- **Analyzing data from sensors is too abstract if students don't understand the sensors.**

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Questions

Is there interest in making the curriculum materials available?

Is there interest (and is there a need) for a facilitator guide that supports the use of a constructivist approach for introductory programming classes at upper elementary or middle school level?

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This slideshow can be found at sepuplhs.org/news

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