Crafting Science

*parts and crafts * Benjamin Brown School • 2016-2017*

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Workshop description
A series of six hands-on, building workshops designed to add a project-based, tangible craft component to a 4th Grade Science class.

Aligned with the Somerville and MA Science Standards.

Target Audience
Fourth graders in the Somerville Public School system. These workshops are designed to be run in a traditional classroom as part of the normal science curriculum but could be easily adapted for other age groups, contexts, and environments.

Course objectives
To provide tangible and hands-on projects using and demonstrating science principles. These projects are aligned to the curriculum standards and should be run to coincide with related coursework. Hands-on projects provide a deeper understanding of physical concepts, aid in the development of scientific intuitions and motivate engagement with academic material.

Materials Needed
Each of the workshops will involve students building a project, device, or scientific instrument and then using that project to investigate an idea or concept.

Each project has unique tool and material requirements which are detailed below.

Students will need ample room to work, either on desks or at tables.

Many of the investigations and discussions make reference to interactive web resources so the projects are made richer if each student or pair of students can have access to a computer.

Session 1

Energy + Electricity

Build a Speaker

- Electricity and magnetism
- Simple circuit design
- Sound as vibration
- What's an amplifier?

Session 2

Energy + Electricity

Build a Monocord

- Mechanical and sonic energy
- Sounds as waves
- Properties of sounds: pitch, volume, amplitude

Session 3

Mechanical + Natural Design

Flapping Wing Mechanism

- Bones and muscles
- Gears and cams
- Wing types and flapping

Session 4

Mechanical + Natural Design

Folding Wing Mechanism

- Wing evolution
- Humans, birds, bats: arms and Wings
- Hinges and linkages

Session 5

Weather, Climate + Data

Build a Thermometer

- What is heat?
- Temperature and kinetic energy
- Ideal gas law
- Calibrating instrumentation

Session 6

Weather, climate + Data

Measuring Wind

- Motors and generators
- Building sensors
- Aerodynamics
- Data collection

Session 1

Energy + Electricity

Build a Speaker

- Electricity and magnetism
- Simple circuit design
- Sound as vibration
- What's an amplifier?

Standards alignment:

- SPS - Create and explain the path of energy in an electric circuit. Identify electric conductors and insulators
- 4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS4-3. Develop and compare multiple ways to transfer information through encoding, sending, receiving, and decoding a pattern.
- 4-PS3-4. Apply scientific principles of energy and motion to test and refine a device that converts kinetic energy to electrical energy or uses stored energy to cause motion or produce light or sound.

Questions: What is sound? What is a speaker? What parts of a speaker move? Why do speakers have magnets? What is an electromagnet? What kinds of sounds sound "good" from our homemade speakers? What do they have in common? What kinds of sounds sound "bad"? What does it mean for a speaker to sound "good" or "bad"?

Activities:

- Make simple noisemakers with popsicle-sticks and rubber-bands. Experiment with making different kinds of sounds.
- Build an electromagnet with magnet wire, nail, and battery pack
- Build papercraft speaker cone and coil. Attach to amplifier
- Attach an amplifier to computer, use tone generators and other software to experiment with different kinds of sounds

Key Terms: VIBRATION: a continuous, rapid back-and-forth movement • SIGNAL: a way of sending electrical information by turning a circuit on and off rapidly • ELECTROMAGNETISM: the relationship between electric currents and magnetic fields interaction of electric currents or fields and magnetic fields • CIRCUIT: a path in which electrons from a voltage or current source flow, usually described as flowing from "power" to "ground • CONDUCTOR: a material that allows electricity to flow through • INSULATOR: a material that resists the flow of electricity

References:

http://partsandcrafts.org/makeit/index.php?title=Cardboard_Speaker
https://www.youtube.com/watch?v=V7xewTc9zZM
https://musiclab.chromeexperiments.com/

Session 2

Energy + Electricity

Build a Monochord

- Mechanical and sonic energy
- Sounds as waves
- Properties of sounds: pitch, volume, amplitude

Standards alignment:

- 4-PS3-1.Use evidence to construct an explanation relating the speed of an object to the energy of that object
- 4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS4-1. Develop a model of a simple mechanical wave (including sound) to communicate that waves (a) are regular patterns of motion along which energy travels and (b) can cause objects to move.

Questions: What is a wave? What is a standing wave? What are properties of sounds? What happens when we pluck a string? How can we adjust a plucked string to change the pitch of the resulting sound? The volume? How can we measure how much a string is vibrating?

Activities:

- Playing with waves.. Make standing waves in slinkies with a partner by oscillating them up and down. Try to make longer and shorter waves in the slinky and observe how you do so.
- Build a monochord out of wood, guitar strings, and screw-eyes. The monochord should have an adjustable bridge to control the note.
- Experiment with tightening and loosening the string. Use a piece of tuning software to tune the string to a specific (but arbitrary) note.
- Divide the monochord into even sections with a ruler. Mark these sections with their measurements and with the note the string produces when you align the bridge with the division.

Key Terms: VIBRATION: a continuous, rapid back-and-forth movement • AMPLITUDE: the strength or maximum distance of a vibration • WAVELENGTH: the distance between peaks of a wave • FREQUENCY: the amount of time between repetitions of a vibration • PITCH: the "highness" or "lowness" of a sound, defined by the frequency of the vibration • VOLUME: the "loudness" of a sound, defined by the amplitude of the vibration

References:

https://www.youtube.com/watch?v=_X72on6CSL0
https://www.youtube.com/watch?v=Qr_rxqwc1jE
https://www.youtube.com/watch?v=n1-pPQNj1_c

Session 3

Mechanical + Natural Design

Flapping Wing Mechanism

- Bones and muscles
- Gears and cams
- Wing types and flapping

Standards alignment:

- SPS - Compare natural systems with mechanical systems designed for similar purposes (ex. bird's wings compared to airplane's wings; satellite dish design vs. ears)
- 4.3-5-ETS1-3. Plan and carry out tests of one or more design features of a given model or prototype in which variables are controlled and failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype

Questions: Why does a bird flap its wings? What is the difference between gliding and flying? How are bird bodies designed for flapping? How can we turn a spinning motion into a flapping motion to model bird flight?

Activities:

- Flap your wings! Watch slow-motion video of flight and copy the motion with your arms.
- Gliding vs flapping. Design and fold a few different paper airplanes. Test them out, what makes them glide? What makes them different?
- How is a bird skeleton similar to a human skeleton? Explore bird biology with Cornell Bird Lab web app.
- Build a flapping wing mechanism. Compare flapping mechanism motion with bird wings. Decorate, modify, and customize your bird.

Key Terms: MUSCULOSKELETAL SYSTEM: the system of the body made up of the bones of the skeleton, muscles, cartilage, tendons, ligaments, joints, and other connective tissue • LIFT: the upward-acting force on a wing • THRUST: the force pushing in one direction caused by pushing mass in the opposite direction • GEAR TRAIN: a system for conveying motion made by mounting gears on a frame so that their teeth interlock • CAM: a piece of a rotating mechanism designed to convert rotational motion into linear motion

References:

https://www.youtube.com/watch?v=3Mr83JjDpL8
http://partsandcrafts.org/makeit/index.php?title=Flapping_wing_kit

https://www.youtube.com/watch?v=3So7OMwNgy8&t=13s

https://academy.allaboutbirds.org/features/birdanatomy/

Session 4

Mechanical + Natural Design

Folding Wing Mechanism

- Wing evolution
- Humans, birds, bats: arms and wings
- Hinges and linkages

Standards alignment:

- 4.3-5-ETS1-5(MA). Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem
- 4-LS1-1. Construct an argument that animals and plants have internal and external structures that support their survival, growth, behavior, and reproduction
- SPS - Identify and analyze animal adaptations and how they relate to survivability in the environment

Questions: How did wings evolve? How are wings different from arms and legs? How can we design a structure to fold and unfold like a bird's wing? What kinds of mechanisms can convert vertical motion to horizontal motion?

Activities:

- What use is half-a-wing? Watch video and read about the "Wing Assisted Inclined Running" hypothesis
- Drawing evolution. Using diagrams of the skeletons of theropods, archeopteryx, and chickens, draw the intermediate stages to create a gradual transition from forelimbs to wings.
- Build folding wing mechanism. Hold the mechanism along your arms see how you have to move your to fold and unfold them.

Key Terms: ADAPTATION: a change or the process of change by which an organism or species becomes better suited to its environment • TRANSITIONAL FORM:fossils or organisms that show the intermediate states between an ancestral form and that of its descendants • LINKAGE: an assembly of pieces and connections designed to control forces and movement • SCISSORS MECHANISM: a linkage that uses movable criss-crossing supports with a pivot between them to turn horizontal motion into vertical motion

References:

http://partsandcrafts.org/makeit/index.php?title=Big_Wings
https://www.youtube.com/watch?v=y3Hw9Sasl8Q

https://www.hhmi.org/biointeractive/the-origin-of-flight-what-use-is-half-a-wing

https://whitebrickedwalls.wordpress.com/2016/12/22/from-dinosaurs-to-birds/

Week 5

Weather, Climate + Data

Build a Thermometer

- What is heat?
- Temperature and kinetic energy
- Ideal gas law
- Calibrating instrumentation

Standards alignment:

- Describe weather in terms of in temperature, moisture, wind speed, and direction
- Differentiate between water as a solid, liquid, and gas
- 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
- 4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4.3-5-ETS1-5(MA). Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.

Questions: What is heat? What is pressure? How does the volume of an object change as it changes state from solid to liquid to gas? What are the relationships between temperature, pressure, and volume? What is wind, and what makes it happen?

Activities:

- Demonstration of gas expansion with dry ice and balloon.
- Demonstration of phase change and pressure change with ice-bucket/soda-can implosion.
- Exploration of ideal gas law and kinetic theory of gases using Scratch simulation
- Make a thermometer with film canister and rubbing alcohol.
- Calibrate thermometer to room temperature and with ice bucket.
- Discuss the difference between a thermometer and a barometer.

Key Terms: TEMPERATURE: the degree or intensity of heat present in a substance • HEAT: the average kinetic energy of the molecules making up a substance • VOLUME: the amount of space that a substance occupies • PRESSURE: the force exerted on an object by a substance in contact with it • THERMAL EXPANSION: the tendency of a substance to increase its area or volume in response to an increase in temperature

References:

https://scratch.mit.edu/projects/17778099/

http://www.instructables.com/id/Be-a-Scientist%3A-Make-your-own-thermometer/

https://www.youtube.com/watch?v=7vTfyAMu6G4

https://www.youtube.com/watch?v=P-G0YkfgdbA

Week 6

Weather, Climate + Data

Measuring Wind

- Motors and generators
- Building sensors
- Aerodynamics
- Data collection

Standards alignment:

- Describe weather in terms of in temperature, moisture, wind speed, and direction
- 4-PS3-4. Apply scientific principles of energy and motion to test and refine a device that converts kinetic energy to electrical energy or uses stored energy to cause motion or produce light or sound.
- 4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-ESS3-1. Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not.

Questions: How can we measure weather? How can we measure wind? What is a sensor? How can we convert physical data into electrical data? How can collect numerical data to analyze with a computer? What makes a good wind sensor?

Activities:

- Build dynamos to turn rotational motion into voltage.
- Use volt-meter to measure voltage produced from motor rotation.
- Build mechanisms to attach to the motor to cause it to spin in the wind. Experiment with designs using box fans as a wind source.
- Use Arduino keyboard-emulator circuit to collect data into a spreadsheet
- Calibrate your wind-sensor by comparing your readings to a commercial sensor

Key Terms: DYNAMO: a machine for converting mechanical energy into electrical energy; a generator • SENSOR: a device that detects or measures a physical property and records, indicates, or otherwise responds to it. • VOLTAGE: a measurement of the electric potential energy between two points • WIND SPEED: the rate at which air is moving from high pressure to low pressure, usually caused by changes in pressure

References:

https://www.youtube.com/watch?v=Af0LB3abBsk

https://create.arduino.cc/projecthub/achindra/diy-anemometer-wind-speed-sensor-device-84a2e3

https://learn.adafruit.com/trinket-usb-keyboard?view=all