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Interactive Cardboard Robots

A Guide from The Creativity Lab

Ankylosaurus robot with programmed light sensor, LED's and servo-motor by Makei and Nicolas.

Author: Sarah H. Chung

Based on Lawrence Hall of Science's Robot Petting Zoo

Special thanks to the Abundance Foundation and Agency *by* Design Oakland for their generous support.

About This Project

This is a fun and creative physical computing project that opens a doorway to [computational thinking] concepts and practices. From brainstorming to designing, engineering and programming, students create their own interactive robots. By programming microcontrollers and various electronic and mechanical components, students make their ideas come to life. This project is an adaptation of the Lawrence Hall of Sciences Robot Petting Zoo, with an additional emphasis on 3D engineering with cardboard.

This guide is designed for facilitating students with little to no prior experience working with programming, robotics or 3D design. This project develops collaboration and time management skills, which are necessary to complete high quality, completed projects by a deadline. Everyone enjoys these interactive robots at community events such as a self organized Maker Faire!

Our Story

In developing the first middle school programming-making class at our school, we wanted to design an initial programming experience that would bridge coding with the physical world. When we decided to use the hummingbird microcontrollers and Scratch, we were open with students regarding the fact that the technology and kits we would be using were very new to us, and that the first trimester would be an experiment that we would all learn from.

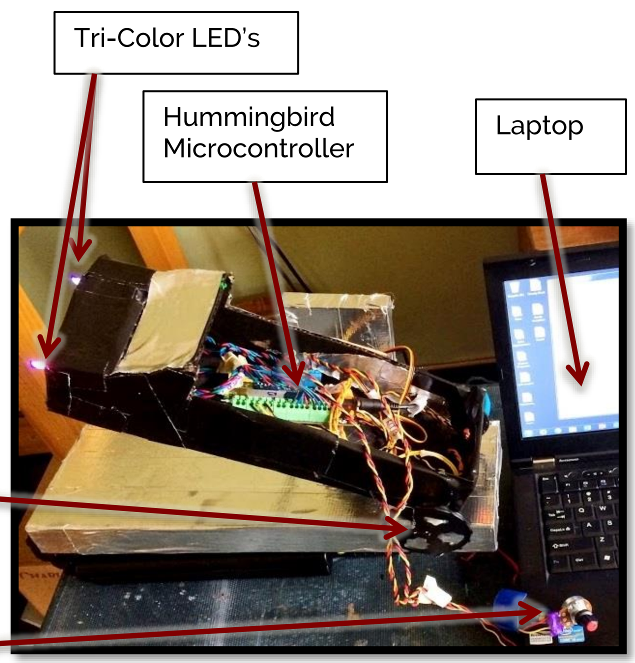
Students were excited to engage with a project and technology that few others had been exposed to before them. As a class, we developed systems and structures that supported a materials and a technology-heavy curriculum. Setting an authentic deadline and audience helped to foster a culture of inquiry, peer-to-peer learning, and active troubleshooting.

Materials

Technology:
Laptops (with Scratch offline version, Birdbrain Robot Server)
Hummingbird Duo Microcontroller kits
Headphones and Portable Speakers

Tools:
Power Strips/Outlets (accessible around the room and safe from foot traffic)
Drills
Box cutters
Cutting Mats
Cardboard scissors
Hot glue guns (high and low temp)
Clamps
Screwdrivers (small for attaching servos)
Leather Awl Tool
Rulers
Pull Saw

Materials:
Cardboard boxes
Hot glue sticks
Wooden Skewers
White Glue
Tape (painters/masking/duct)
Scrap wood pieces
Wood screws
Paint



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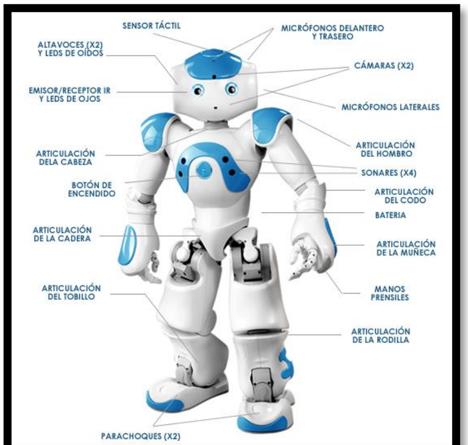
CONTEXT: Before we MAKE...

Interdisciplinary and Real World connections:
Start by discussing the questions: What is programming? What is a robot? Using different resources, expose students to real-world and evolving applications of designed and programmed robotics.



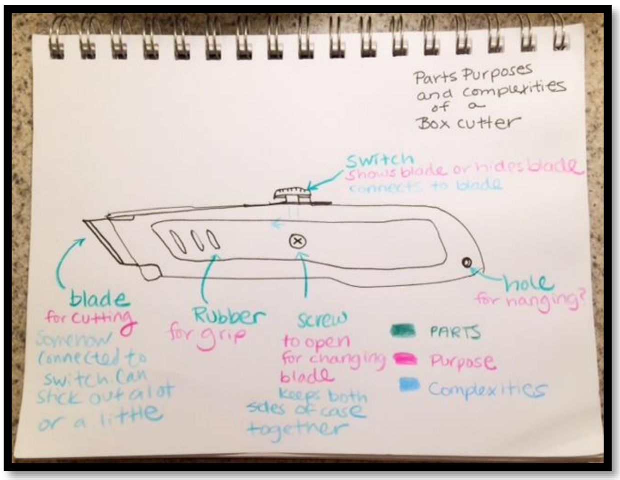
Here are a few videos that we have used:
Anouk Wipprecht integrates Audi parking sensors into 3D-printed fashion:
https://www.youtube.com/watch?v=RUOd8uku6Og
Aldebaran Robot "Nao":
https://www.youtube.com/watch?v=nNbj2G3GmAo
10 Amazing Robots:
https://www.youtube.com/watch?v=6feEE716UEk

How to Organize Tools & Tech SAFELY

Organizing Materials:
We recommend that materials, tools and technology equipment for this project be organized by items that are readily available to students vs. sensitive materials that are stored in a teacher-access only storage. Maintaining a check out system ensures that expensive and delicate materials are tracked and accounted for, especially when working in shared classroom spaces. Being organized and having clear systems builds a culture of the respect and care necessary to ensure longevity of the equipment.

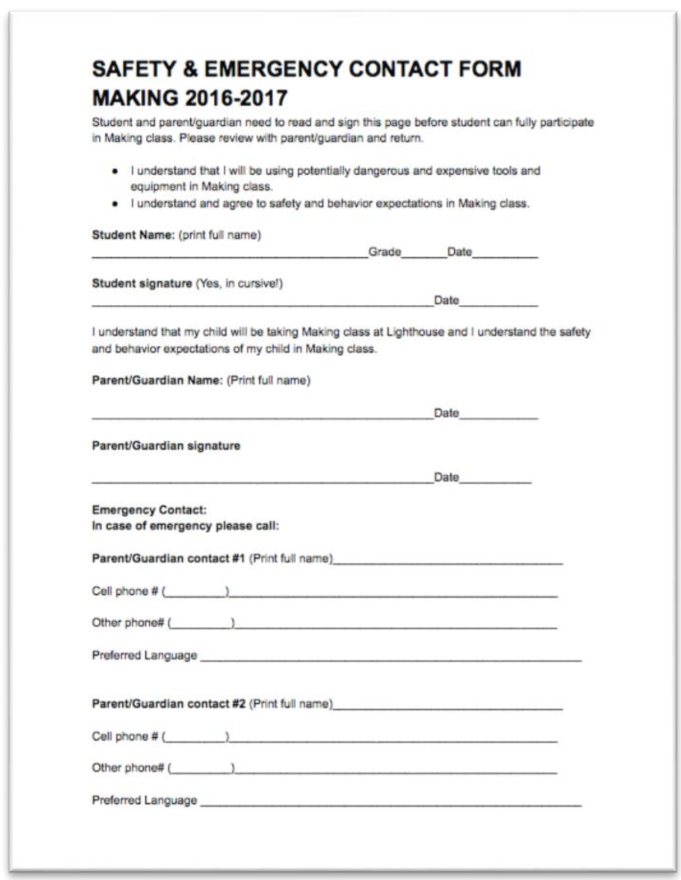
Examples of sensitive materials (potentially hazardous or expensive): Computers, headphones, microcontrollers, box cutters, soldering irons, high heat glue guns, plus other items at your own discretion.
Student accessible materials (tools and materials that are generally safe and easy to replace): Rulers, scissors, tape, wire, pliers, multi-meters, calculators, low temp hot glue guns, paint, plus other items at your own discretion.

Student Led Systems and Agreements:
An activity called Parts, Purposes, Complexities, from Agency by Design, is a great activity for introducing new tools and technology. Visually deconstructing new materials and tools empowers students to think critically about their function and design. As students become familiar with new tools and materials, they contribute their ideas for best practices in using these tools. When students influence and inform systems and shared agreements in the classroom, they tend to adhere and hold each other accountable for these agreements.



Once systems and rules have been developed, we send students home with a safety contract to be signed by both student and parent or guardian. This contract collects important emergency contact information, as well as encourages family involvement and awareness of the content of the classwork.

After brainstorming ideas of best practices, we voted on the most relevant and clear agreements. Then, we created a poster for the wall as a daily reminder.



SAFETY & EMERGENCY CONTACT FORM
MAKING 2016-2017

Student and parent/guardian need to read and sign this page before student can fully participate in Making class. Please review with parent/guardian and return.

- I understand that I will be using potentially dangerous and expensive tools and equipment in Making class.
- I understand and agree to safety and behavior expectations in Making class.

Student Name: (print full name)
______________________________Grade______Date_________

Student signature (Yes, in cursive!)
______________________________Date_________

I understand that my child will be taking Making class at Lighthouse and I understand the safety and behavior expectations of my child in Making class.

Parent/Guardian Name: (Print full name)
______________________________Date_________

Parent/Guardian signature
______________________________Date_________

Emergency Contact:
In case of emergency please call:

Parent/Guardian contact #1 (Print full name)______________________

Cell phone # (________)______________________

Other phone# (________)______________________

Preferred Language ______________________

Parent/Guardian contact #2 (Print full name)______________________

Cell phone # (________)______________________

Other phone# (________)______________________

Preferred Language ______________________

Cardboard Robots

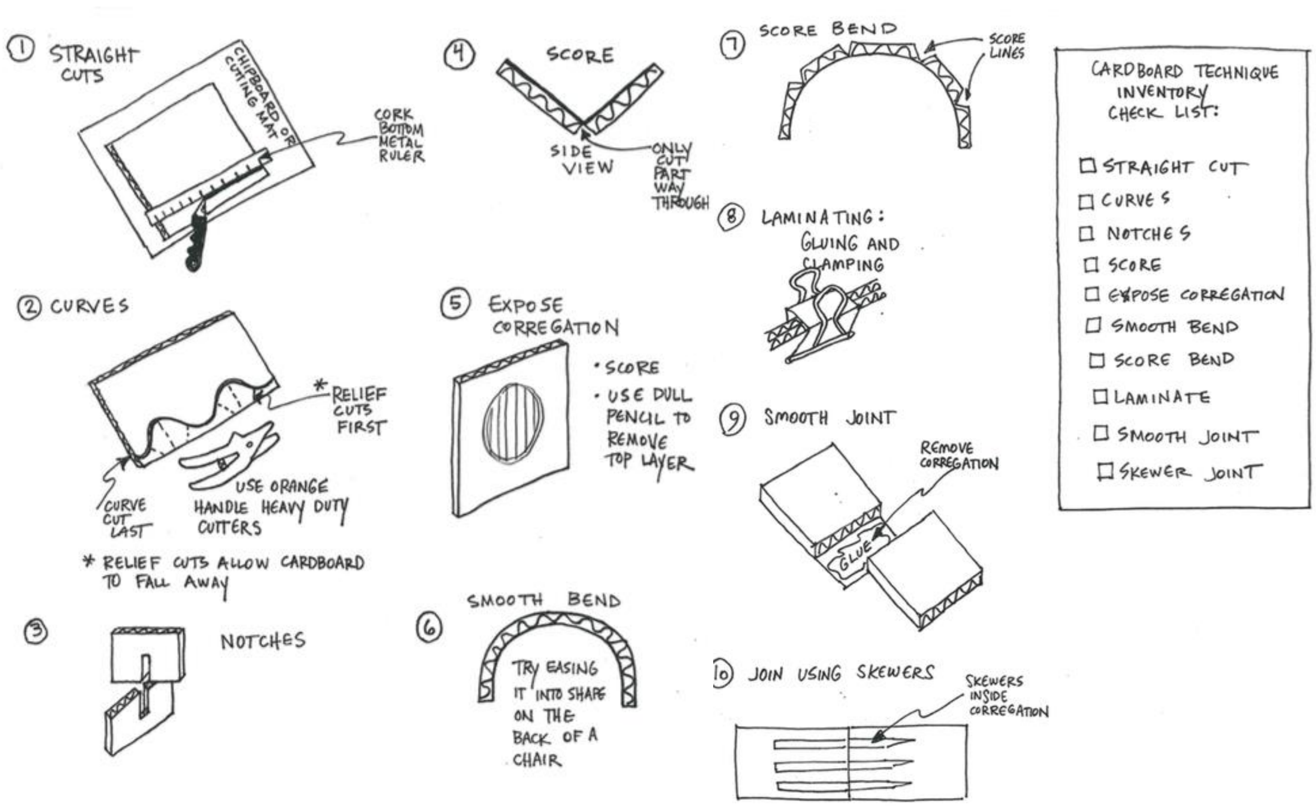
Basics of 3D Design using Cardboard:
During this first phase, we encourage students to build using demonstrated techniques with little restrictions. The goal is to generate and prototype ideas for their robots, and to get comfortable using the tools & materials for building in cardboard.

We encourage students to come up with new joining techniques, beyond the 10 listed below. Through journal entries and peer dialogues students reflect on the structural integrity and aesthetics of designs as they are developed.

Tip: When collecting corrugated boxes it is helpful to cut them down into small/medium/large panels to save time and decrease cardboard waste.

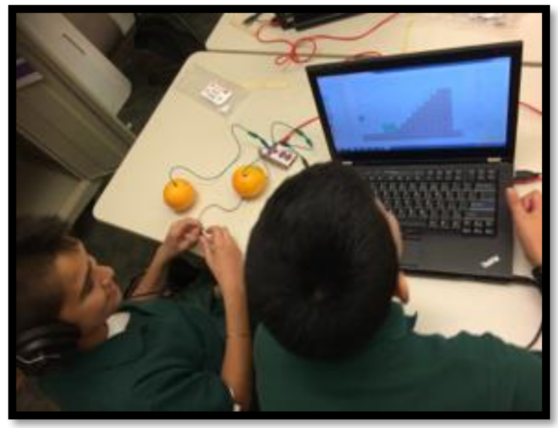
Safety Tip: Label and assign sharp tools to groups/tables or create specific workstations for cutting/gluing in the classroom.

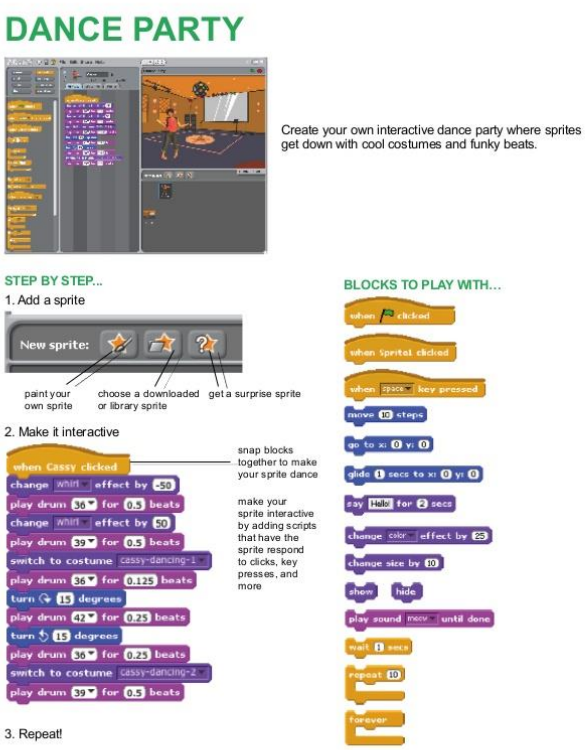
For more information – check out Erin Riley's [cardboard building resources]!



Cardboard Robots (continued)

Introduction to Programming in MIT's Scratch:
Now that students are excited and invested in possible robot ideas, it is time to introduce the programming space and language, MIT's Scratch. We start by using the online version and exposing students to the vibrant online Scratch community. Also helpful is Scratch's educational resource on Computational Thinking Concepts/Practices and Perspectives.





Students are partnered 2 per laptop and practice learning through partner programming to ensure that both people are engaged and working together. This means one person "drives" the laptop and thus, they are the only one using the keyboard and mouse, while the other person is the "navigator" and verbally directs the moves of the driver.

For our first project, students create an animated dance party where dance moves and sounds are programmed and controlled by keyboard keys. This is a fun and easy way to learn the interface of the Scratch software. Check out this and other project ideas from Scratch Ed.

Giving students opportunities to share their discoveries in the classroom and the online scratch community reinforces the peer-to-peer learning style of sharing and learning within a community.

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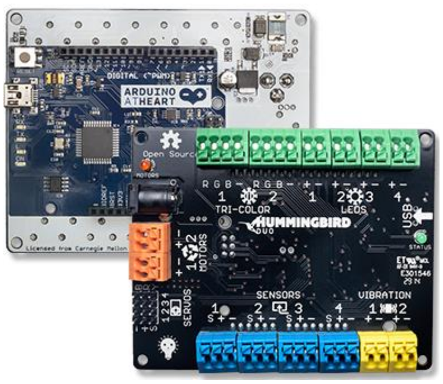
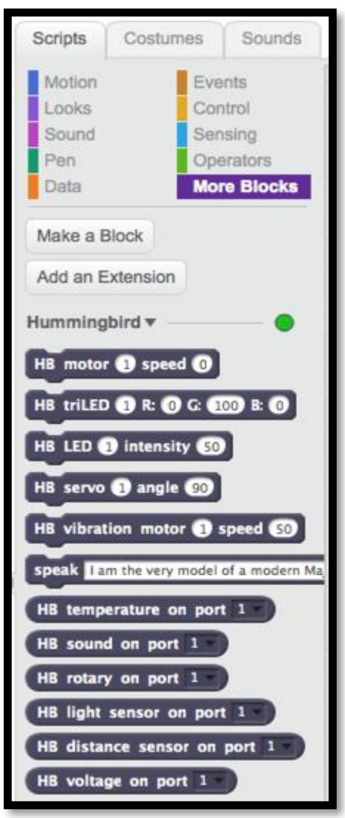
Cardboard Robots (continued)

Physical Computing with Hummingbird Microcontrollers:

Once students have basic understanding on how to use the Scratch programming software, it is time to move into the world of Physical computing! We used the Arduino based Hummingbird Duo Microcontrollers, which are educational kits made by BirdBrain Technologies.

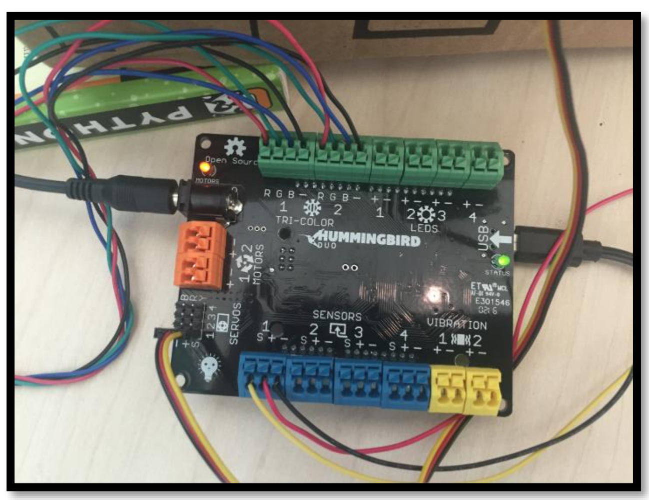
In order to connect Scratch with the Hummingbird on a PC or Mac, you will need to install and use the offline version of Scratch. Then install the helper application, the Bird Brain Robot Server. Once these are installed you should be able to see the extra purple blocks in the more blocks menu of Scratch (see image to the left). There are many other programming options to explore.





Working in pairs, students take turns being the electrical engineer, the one who would connect wires and handle the kit components, and the programmer, the one on the laptop on Scratch. Assigning a series of design challenges is a fun way to motivate students to work together to figure out how to connect and make components work.

1. Make a Tri-color LED light up.
2. Make the Tri-color LED blink two colors.
3. Make a 360 motor turn clockwise and counterclockwise.
4. Program a light sensor to make an LED flash different colors depending on the amount of light.
5. Program a sensor to make the motor turn at different speeds or directions



Tip: Introduce components a few at a time as to not overwhelm students with all the options. This also helps keep track of the parts when working with large groups.

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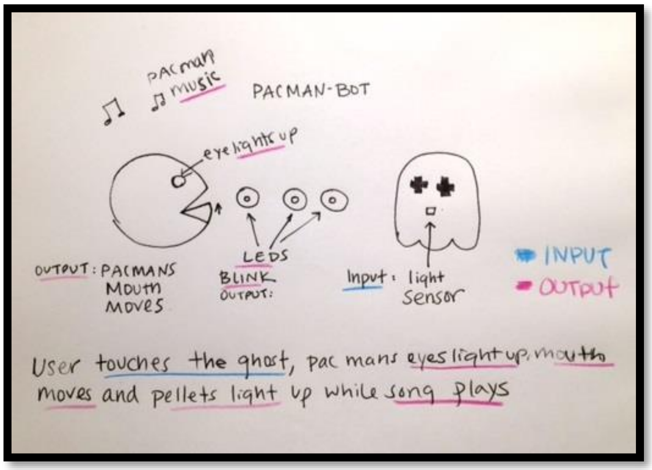
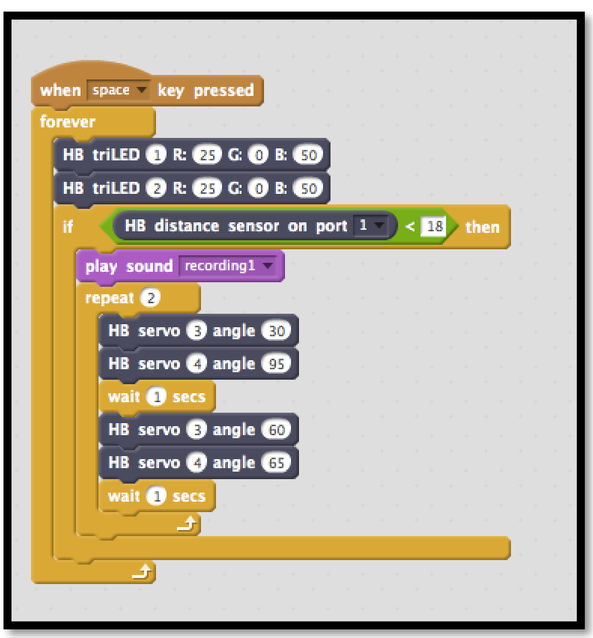
Integrating Cardboard Engineering, Programming and Physical Computing:

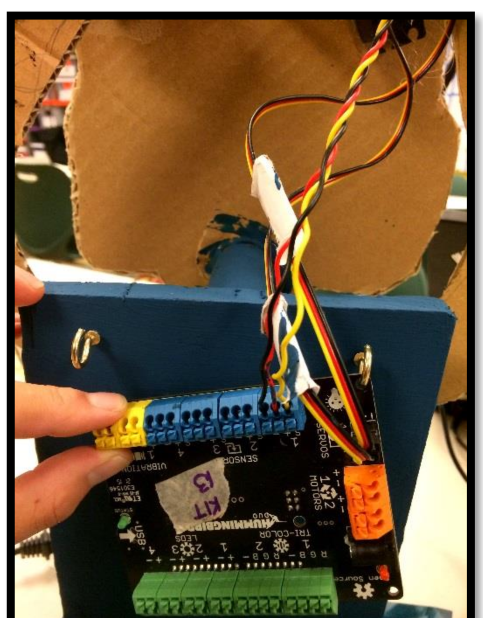
Once students have explored 3D engineering in cardboard, programming in Scratch and programming a microcontroller, it is time to integrate these skills in designing, prototyping building and programming the final interactive cardboard robots!



Students brainstorm different ideas of robots they wanted to create, and sketch their ideas in journals. They label the components they would program as inputs and outputs for their design. Working in groups and rotating through the roles of programmer, electrical engineer, structural engineer and artist, students collaborate to work through a variety of creative problems in bringing their design to life. Throughout the process they reflect on which aspects of the project they enjoy, are challenged by or had to persevere through.

After spending weeks building, programming and decorating, presenting these complex and interactive projects at public events offers a strong sense of accomplishment and joy for students. Students exhibit a strong sense of pride and ownership of these projects. After completing this project, students more strongly identified as a makers, programmers, creative engineers and artists.





Example of student created code and hummingbird attached to cardboard robot

Reflection & Community Connection

Who is authentic audience for these projects?
Having a real deadline and public exhibition of work is an important aspect to motivating a collaborative group project. Creating or participating in a community event outside of the classroom is an exciting way to provide real feedback and genuine success of student work. Exhibiting complex and creative work is intrinsically gratifying.

How will students reflect to cement learning?
Students create and maintain a journal as a place to sketch ideas, designs, track their short and long term goals as well as reflect on the work sessions.

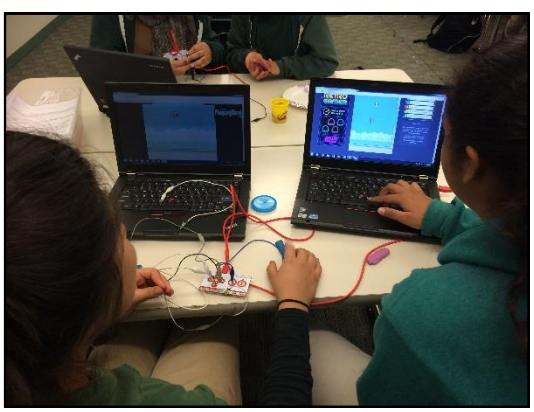
Students are pictured here exhibiting their robots at East Bay Mini Maker Faire

Related Extension Projects

Makey Makey

A great way to introduce students to microcontrollers that bridge to the physical world is by having them connect their Scratch projects to a Makey Makey kit. They can connect any conductive materials and have them in place of the programmed keys. Suddenly bananas, playdoh and even a friend can be the trigger of the dance party or animation on the screen!

http://www.makeymakey.com



Programming Journal Pages

The Electric Notebook:
The electric notebook idea was inspired by Jie Qi, Natalie Freed, and Nexmap's paper circuit 21st Century Notebooks and is a novel approach to meet STEM and NGSS engineering standards of integrating technology and engineering design and modeling concepts of fabrication and prototyping.

http://jeanninehuffman.weebly.com