

“Hack A Banana”
The Playful Side of Engineering — Using Cool Tools to Teach and Help Others

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Introduction

Engineering- (n) Engineering involves the application of creativity in partnership with math, science, social studies, language arts and fine arts to search for quicker, better and less expensive ways to use the forces and materials of nature to meet today's challenges. Engineers are problem solvers who use every resource possible to bring into existence things and ideas that they imagine. (www.wsfcs.k12.nc.us/Page/67517)

With the technological world taking over every part of our lives, problem solving must be the primary focus for a new generation of children who are growing up as digital natives, but who are not prepared to solve the problems that our future holds.

Steve Jobs once said, “I think that everybody in this country should learn how to program a computer because it teaches you how to think.” Steve Jobs- The Lost Interview. It does teach you how to think, and so began my journey into the world of programming this March, when I introduced the Hour of Code, a nationwide initiative by CSEdWeek and code.org to encourage my students to learn how to program computers. Most students loved it immensely, but there were some who were frustrated because they did not have the skills necessary to persevere until they achieved success.

This included myself, a person who loves to explore but who also loves knowing how to find solutions to problems. The differences that allow some of us to find these answers are that we do not give up when faced with challenges. We take detours when our options

seem exhausted. We keep trying, no matter what, until we do find that possible glimmer of hope.

Some students could not handle failure and withdrew, while others were able to persist until they figured out the solutions. Why were some children able to fail and keep trying? As a teacher who only saw them once per week, how could I teach them that confusion and mistakes are the first steps in the learning process, and that learning will take place if they persisted? Creating an environment where children were told that it was okay to make mistakes and where experimenting was safe obviously, was not enough.

It reminded me of when I first attempted to learn how to use computers in the 80's when I was first introduced to computers as an art teacher, and I tried programming using Logo. It frustrated me immensely and I lost interest until a teacher hooked me using my passion in art. Instead of programming, he taught me how to draw and paint using basic tools. I grew to love it so much that I eventually switched into teaching computer technology, and continue to teach creativity through the medium of computers and digital applications.

Overview

I began to research programming for young children and discovered a website called Tynker that used visual logic to solve puzzles. For older elementary students we explored the Hour of Code activities at Code.org to get the evil pig from Angry Birds to complete his missions. They loved it, and I loved it. If I could get kids to solve those games using visual logic and if-then statements, then surely this would extend into solving many of the day-to-day problems they would find in the real world.

How would I connect what I was doing in the classroom to what I was doing in my robotics seminar? How will my students use play to explore ways to solve problems and use objects in ways other than their original purpose?

While using arduinos, building circuits and programming a robot to do a dance may be more geared to middle school and high school students, my students would love to get their hands on computer and gadget insides. If students were allowed and encouraged to take apart broken components and learn about what they do, it just might be an introduction to how to put those components together to create something with a specific purpose. How could the bulb and electronics in flashlights be used to light up in some other way? What about using play dough to create circuits as in “squishy circuits”?

In role-play, young children love to invent objects from whatever is in their environments, so how can we teach children to invent new ways to use old objects in ways they never thought of? Could a dollar store flashing light serve some other purpose if we took it apart and used the diodes or circuitry with other electronic components?

Children will deconstruct, and reconstruct in an attempt to break down barriers to their thinking and to build unusual and fun ways to create circuits. Students will use scientific discovery to explore the possibilities.

Students will also create models using **Legos®** as ways of visualizing what a robot that performs a specific task may look like, and be able to think about modifications when using simple machines. A robot that would perform a task would need certain parts in order to do that task, such as a moving part that would have wheels or things that turned. Students would learn how to adjust their abstract thinking into making a concrete model.

This unit will take an invention created by Jay Silver and Eric Rosenbaum, who work for MIT's Lifelong Kindergarten Group at MIT Media Lab, called "**MaKey MaKey®**", and students will use it to discover their world in ways they never thought of. The MaKey MaKey kit allows students to take everyday objects to create a touchpad soundboard using an object, the elements in the kit and a computer. The possibilities are endless.

Students will solve programming puzzles using interactive websites and will create their own activities.

Rationale

As a person who never stops learning, I continually look for ways to experience my world and increase my understanding of the world around me. The expression "Think outside of the box." has always resonated with me as I try to solve problems and create new challenges for myself.

This is how I approach my work as a teacher, offering new experiences for my students to use their minds to solve problems and to dig inside for creative ways to solve them. Part of this journey to explore is to play, to find new ways to do old things. "The creative adult is the child who survived."- U. LeGuin

Many students do not know how to do this because they have been taught to give answers to problems with only one solution. Education in our school district is now focusing on creating a new generation of independent thinkers.

Teachers are being asked to become facilitators for the 21st century classroom where students are the explorers and seekers of information- where students teach and learn from each other to solve problems they may not be able to on their own. This allows students to rely on their own learning strengths to bring to the cooperative learning environment. Programming is a perfect vehicle.

As we prepare students for the future, how do we change the way we teach them for jobs that have not yet been created? How do we guide them to choose which fields to pursue? What qualifications will they need to pursue these careers if we don't even know what they are? We don't have those answers but we do know we can teach them how to think creatively, how to solve problems in different ways.

Materials

MaKey MaKey®

Playdough®

Legos®

Snap Circuits®

Drawdio musical pencil- a homemade drawing circuit using a pencil, a thumbtack and an integrated circuit

Objectives

Through discovery, students will learn what objects act as conductors and which ones act as resistors. Playdough® can become piano keys. A pencil can make sounds as it writes. What other possibilities will they find that haven't yet been tried?

My hope is that students will be inspired to pursue a career in STEM- Science, Technology, Engineering and Math by engaging in play, and in developing ways to explore their world as though experiencing it for the very first time, much like when babies learn to interact with their worlds. Babies do not know the purposes of things and explore by sight, sound, taste, touch and smell. What if MaKey MaKey® can make the color red hum on a computer screen? I am excited by the possibilities.

The learning objectives consist of learning to identify ways of solving problems, learning ways to try alternate solutions when initial attempts do not work, and finally how to apply the rules for seeking these solutions to other areas of the curriculum and to everyday life situations as well. When a person learns how to use persistence to solve problems, they will have developed a strategy for life long learning.

Students also will begin to think of themselves as learners and will begin to think about how they think, a term known as metacognition. It is necessary for us as teachers to encourage our students to think for themselves, to figure out solutions for problems on their own before we respond and to teach students how to brainstorm to come up with creative ways to solve problems. This will lead to self-discovery and the ability to use critical thinking skills to analyze situations and produce solutions that are outside of the box.

Strategies

Students will complete games at a website designed for students in Grades 1 and up called Tynker, as a way of building confidence in using visual logic. Older students can also design their own games and activities using the tools supplied by the website for classes that are set up by teachers.

Advanced students will use the website Code.org for more involved play, and Scratch, a free program for students also designed by the Lifelong Kindergarten Group at the MIT Media Lab to program their own interactive stories, games, and animations.

“Scratch helps young people learn to think creatively, reason systematically, and work collaboratively — essential skills for life in the 21st century.”

<http://scratch.mit.edu/about/>

What The Unit Will Consist of:

Students will learn the basics of making simple circuits through game play such as lighting diodes, sounding buzzers, and will construct simple games such as **Operation**, whereby students create a circuit with a buzzer. They will explore how to make clay that is conductive in order to make squishy circuits and to enjoy the simple act of exploration of common objects to create sound from everyday things. There will be an element of magic to each experiment.

Students will also use the MaKey MaKey® kit to learn how to use everyday objects in programming music and sound on computers in completely unusual and creative ways. Some of the projects I plan to explore with my students are how to solve simple coding puzzles using visual logic at websites such as Code.org, Tynker, Gamestar Mechanic,

Students will visit the interactive website Code.org. It is designed for students in grades K-8. Students will solve puzzles in a course that aims to demystify computer science and show K-8 students that it's fun, collaborative, and creative. The course is designed to motivate students and educators to continue learning computer science to improve real world relationships, connections, and life.

It will foster an environment of communal learning that emphasizes risk-taking. This course will teach students about computer science, computational thinking, and programming. It will also teach that success does not come on the first try, just like the world's most difficult problems aren't solved on the first try. Challenge is good when plans and tools that lead to success support it.

The website Tynker is designed for Grades 4-8. The puzzles and creative activities are designed to teach students computational thinking and the basics of computer programming.

Students will also learn how to design their own stories, games and activities at Tynker.

Gamestar Mechanic- ages 9-14 Gamestar Mechanic is a game and online community that teaches kids how to design their own games, how to solve problems creatively, uses writing and storytelling, utilizes 21st century skills and creates a motivation for STEM learning.

Who The Target Students Are

This unit will be designed for students in Grades 5 and 6 to be completed over a period of 6 weeks, once or twice per week. It is probable that some gifted students will also attend an afterschool activity to make special projects in electronics and basic integrated circuits using “kitchen science”.

Exceptional students may receive extra instruction once or twice per week, depending on interest and response.

Classroom Activities

Introduction to Applications from the Lifelong Kindergarten Group at MIT

My discovery of the projects that were developed by the Lifelong Kindergarten Group at MIT ignited my passion for developing this unit for use in elementary school. Who wouldn't want to hack a banana into a keyboard or make sounds when drawing with a pencil! It is my hope that through play, we may inspire a new generation of engineers and creative thinkers. I may not be a new generation but I am as excited as any child by the ideas that follow.

Singing Fingers

This is an iPad app that allows users to paint and make sounds. The user is then able to play the painting, by touching the paint and can create a song by experimenting with the various sounds that were recorded as the painting was made.

Drawdio and Sketchio

These are two devices that are created from a pencil or any drawing or painting medium by attaching a small integrated circuit with a speaker. Using the graphite in the pencil or other conductive materials, a person can then create sounds by creating a closed circuit with the pencil or art tool. Imagination and exploration allow for a variety of tools and experiences to be achieved, including adding water, drawings and other ways to make or resist the circuit.

Scratch

Scratch is a basic program that was designed for children to create their own interactive activities using drag and drop programming, utilizing if-then statements. Programs can be saved and uploaded for use by other students on their website projects at Lifelong Kindergarten Group at MIT.

Squishy Circuits- a project designed at the University of St. Thomas to put electronics in the hands of young students without using dangerous soldering irons and confusing prototype boards. The idea sprang up from play-dough, which uses salt and conducts electricity. If you change the recipe and use sugar, it resists electricity. So if you put them together, you have a circuit. Using a simple lead battery pack and an led, you can create a circuit and light the led. The possibilities in the elementary classroom are mind boggling, because young children will be mesmerized, just like we are.

Lesson Plan One

Creating Simple Circuits

Experiment 1- Make a Battery- "The Lemon Battery"

Materials

- A lemon
- A copper nail
- A zinc nail
- Some insulated wire (plastic coated)

How to do

- Cut two pieces of wire about 6 inches long.
- Remove 1 inch of insulation from each end of both wires.
- Wrap the bare wire around each of the nails.
- Stick the nails in the lemon about two inches apart.
- Touch the other ends of the wires to your tongue.

Result

- You will feel a tingle on your tongue.
- Try using other types of fruit to see whether you get the same results.

Experiment 2- Conductivity- "Complete a Circuit"

Materials

- Battery, size C
- Piece of aluminum foil, about 4 inches by 12 inches
- Light bulb from a flashlight

How to do

- Fold aluminum foil several times to make a strip 12 inches long and about 1/2 inch wide
- Set the battery on one end of the strip
- Hold the metal base of the light bulb to the other end of the battery.
- Touch the metal base of the light bulb with the aluminum foil strip.

Result

- The bulb will light up

Why

- The aluminum foil strip makes a path for the energy in the battery to follow.
- The energy follows the path and lights up the bulb.

Experiments

- Try different sizes of batteries
- Try stacking two batteries together
- Try touching the strip to different places

Lesson Plan for Webquest

Students will choose a project to complete to learn about electricity and building circuits from the following website:

http://corder.wrightcity.k12.mo.us/Science/ScienceLinks_files/Electricity%20WebQuest.htm

Scoilnet- games and activities for kids

http://www.scoilnet.ie/Themepage_electricity.shtm

Blobz- Game for 1-5 players

<http://www.andythelwell.com/blobz/guide.html>

BBC- Changing Circuits-

http://www.bbc.co.uk/schools/scienceclips/ages/10_11/changing_circuits_fs.shtm

↓

Build Your Own Circuit-

http://www.cleo.net.uk/consultants_resources/science/circuitWorld/circuitworld.html

Lesson Plan for Squishy Circuits

The main point of this lesson is that you don't need to be an electrical engineer to get some hands-on experience with circuits. You don't need to use a soldering iron or a prototyping board or circuit diagrams in order to start learning about electricity. In fact, all you need is some play dough to start building your own circuits. This circuit technology is a fun way to introduce kids to circuit design with a toy that is familiar, safe, and easy to manipulate.

Electrical circuits are used in a wide variety of applications, from a simple light bulb to complex printed circuit boards for computers and smart phones.

Introduction

Would you rather teach a kid about circuits with soldering irons, prototype boards, and circuit diagrams ... or would you rather teach them with playdough?

This lesson plan includes recipes for two kinds of playdough: conductive dough and insulating dough. These two kinds of playdough can be used together to introduce kids to the fundamental concepts that make electrical circuits work.

In order to build a circuit, we must provide a continuous path for electricity to flow from a power source (for example, a battery), through a conductor, into a device that uses the power (for example, a light bulb), and back through another conductor to the power source. This is called a closed circuit. If this continuous path is broken anywhere, electricity will not flow and the light bulb will not work. This is called an open circuit. If the conductors in a closed circuit are touched together, it forms a new type of undesirable circuit called a short circuit. Electricity will still flow through the circuit, but the light bulb will not work. This is because the light bulb has a higher resistance than the conductors, and the electricity is "lazy" – it would rather travel through the conductors when they are touching than exert extra effort to travel through the light bulb.

There are two types of closed circuits: series and parallel circuits. Series circuits only provide one path for electricity to flow. Parallel circuits provide multiple paths for electricity to flow.

Student Objectives

After completing this lesson, students should understand the following concepts:

- Conductors vs. insulators; resistance
- Open circuits vs. closed circuits; short circuits
- Series circuits vs. parallel circuits

Overview of Lesson Process

Survey students' prior knowledge (5-10 min). Introduce concepts of conductors, insulators and resistance.

Demonstrate open, closed, and short circuits. Also demonstrate series and parallel circuits.

Finally, briefly discuss safety when experimenting with electrical circuits!

Activity (30 min). For the first ten minutes, students should build their own simple circuits to understand the concepts just introduced. Students can then design and build their own circuits to further explore these concepts.

Wrap-up discussion

Which circuits worked and which didn't work? Discuss why the ingredients in each dough affect how easily electricity can flow through each of them. Show images of disassembled electronic devices, like laptops, iPods, iPhones, etc.

Materials

- Flour
- Salt
- Cream of tartar
- Vegetable oil
- Food coloring
- Sugar
- Distilled water
- Granulated (powdered) alum
- 9V battery (4-pack)
- Heavy-duty 9V snap connectors (5-pack)
- 10 mm LED assortment

Squishy Circuits Recipes

Conductive dough recipe [<http://youtu.be/cpUFL5LZpv4>]

Playdough, or make your own from the following recipe

- 1 cup (tap) water
 - 1 1/2 cups flour
 - 1/4 cup salt
 - 3 Tbsp. cream of tartar
 - 1 Tbsp. vegetable oil

- food coloring (optional)

Insulating dough recipe [<http://youtu.be/Wz8rGNt-iEQ>]

- 1 ½ cup flour
- ½ cup sugar
- 3 Tbsp. vegetable oil
- 1/2 cup deionized (or distilled) water
- 1 tsp. granulated alum (optional)

Procedures

Prepare batches of conductive and insulating dough ahead of time. Each recipe above makes enough dough for 2 groups of 4-5 students.

Students design and build their own circuits. For example, they can build circuit sculptures. First, have the students sketch their designs on paper. Then, they can build and test their designs. Creating animals with light up eyes is a great one as well as using a small toy motor for a spinning tail.

Wrap up discussion

Discuss which types of circuits worked and which didn't.

What is the difference between a series and parallel circuit?

Why does one dough conduct electricity and the other doesn't?

Tips for Safety

Don't connect the 9V battery directly to the LED, it may burn the LED out.

Try not to mash the two types of dough into each other. This makes it difficult to separate them for future classes.

The LED only works in one direction. This is called polarity. Notice how one "leg" of the LED is slightly longer than the other one. The longer leg should always be attached to the positive (red) wire from the battery.

Sometimes, thin strands of insulating dough will still conduct some electricity, and the LED will become dimly lit. If this happens, use it as an opportunity to discuss resistance!

Don't cross the wires on the battery connectors – this will short out the battery! It may heat up and explode.

Warn students to always be careful when experimenting with electricity. High voltages and high currents can be deadly. For example, they should never stick wires or other objects into wall sockets. It's best to always do these activities with adult supervision.

Resources (as included in the Lesson Plan)

1. <http://courseweb.stthomas.edu/apthomas/SquishyCircuits/index.htm>
2. http://www.ted.com/talks/annmarie_thomas_squishy_circuits.html

3. <http://courseweb.stthomas.edu/apthomas/SquishyCircuits/PDFs/Squishy%20Circuits%20Classroom%20Guide.pdf>
4. <http://www.toysaretools.com/2011/12/electrify-your-childs-learning-through.html>
5. <http://www.wellersolderingiron.co.uk/images/2.jpg>
6. <http://lochierferrier.files.wordpress.com/2011/10/2011-10-11-11-47-21-422.jpg>
7. <http://bidboomerang.com/wp-content/uploads/2011/10/light-bulb-battery-circuit.jpg>
8. <http://www.blogonono.net/wp-content/uploads/2011/08/Printed-Circuit-Board.jpg>
9. http://4.bp.blogspot.com/-a5CFI3hL_TA/TsIiL7FTcII/AAAAAAAAAVg/hTYTV7oNU0A/s1600/disassemble-iPhone-4s.jpeg
10. <http://www.onlytechnews.com/wp-content/uploads/2011/12/iphone-4s.jpg>

Squishy Circuits Worksheet

(adapted from Squishy Circuits Classroom Guide,
<http://courseweb.stthomas.edu/apthomas/SquishyCircuits/PDFs/Squishy%20Circuits%20Classroom%20Guide.pdf>)

1a. Begin with two lumps of the conductive dough.

Plug one wire from the battery pack into each piece and bridge the gap with a LED.

Does the LED light up? (Circle one): YES NO

1b. Take the LED out and flip it around so that each “leg” is in the opposite piece of conductive dough.

Does the LED light up? (Circle one): YES NO

The LED only works in one direction. The longer terminal should be attached to the positive (red) wire from the battery pack. This is called a closed circuit.

2. Next, pull one of the LED legs out of the dough.

Does the LED light up? (Circle one): YES NO

In the last step, the LED went out because we broke the loop of electricity – this is called an open circuit. 3. Put the LED leg back in, so your LED is on. Now, push the two pieces of conductive dough together.

Does the LED light up? (Circle one): YES NO

In the last step, the LED went out – this is called a short circuit.

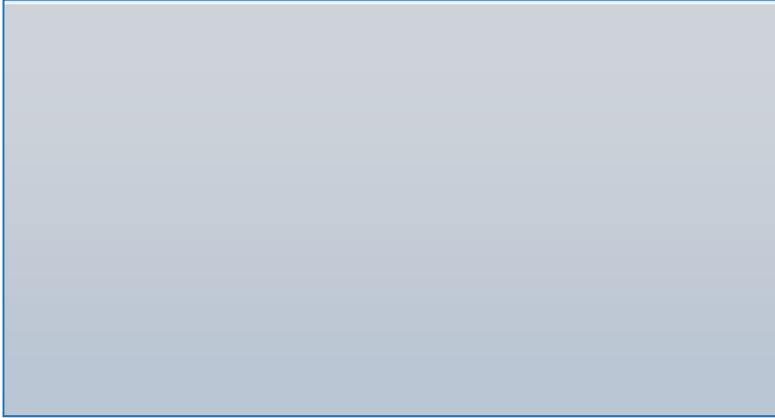
4. Separate the two pieces. The LED should once again light up, because the electricity must go through the LED to complete the circuit. Now, create a “sandwich” with the insulating dough between two pieces of conducting dough.

Does the LED light up? (Circle one): YES NO

The insulating dough does not let electricity flow through it easily. It acts like a “wall” to electricity. Therefore, the electricity has to go around the insulating dough, and through the LED, which lights up! There is one continuous path for the electricity to flow through – this is a series circuit.

5. Now, we can create Squishy Circuits that do not have to be separated, like “sushi circuits!”

There are multiple paths for the electricity to flow through – this is a parallel circuit. 6.
Now, you can design your own circuit! Draw your design here:



Now, try to build and test your design with the materials provided!

Standards

Technology

3.7.5.C.1: Describe how computers can be used to solve specific tasks utilizing specific software for educational purposes.

3.7.5.C.3: Use input and output devices to capture, store, and present images.

3.7.5.D: Use basic computer software.

3.7.5.D.1: Identify specific software applications appropriate for the task.

3.7.5.D.2: Use built in Help applications embedded in each software package.

3.7.5.E: Explain basic computer communications systems.

3.7.5.E.1: Explain how computers can be used to record and store data, to access data easily and to provide a means to display it, manipulate it and share it.

Algebraic Concepts

2.2.5.A.4: Analyze patterns and relationships using two rules.

Science

3.1.5.A.1: Describe a system as a group of related parts that work together to achieve a desired result. (e.g., food web, airplane).

3.1.5.A.2: Explain the importance of order in a system.

3.1.5.A.3: Recognize the parts of a system (e.g., system inputs, system processes, system outputs).

3.1.5.A.4: Examine a system to ensure that it is complete.

3.2.5.A: Identify and use the nature of scientific and technological knowledge.

3.2.5.A.1: Answer “What if” questions based on observation or prior knowledge.

3.2.5.A.3: Recognize how uncertainty about an accepted scientific explanation led to a new understanding.

3.2.5.B.3: Communicate, raise questions, and formulate hypotheses, test and experiment.

3.2.5.C: Recognize and use elements of scientific inquiry to solve problems.

3.2.5.D: Recognize and use the technological design process to solve problems.

3.2.5.D.1: State the steps of the technological design process (e.g., problem identification, solution design, implementation, and evaluation.)

3.2.5.D.2: Recognize different types of problems and propose possible solutions.

3.7.5.A: Explore the use of basic tools, simple materials and techniques to safely solve problems.

3.7.5.A.1: Describe safe procedures for using tools and materials.

3.7.5.A.2: Demonstrate proficiency in the safe use of tools.

Bibliography/Works Cited/Resources

Bibliography for Students

Student Apps for Programming

Hopscotch for iPad- learn basics of programming- **Hopscotch** is an **iPad** app that lets kids drag and drop blocks of code to create interactive art and apps. Designed for ages 9-11

Daisy The Dinosaur for iPad- teaches programming to the youngest students- grades 1-5

Cargo-Bot for iPad teaches kids how to program by having a robot arm move around Tetris-like blocks. Ages not specified but reviews mention kids as young as 4 with parental guidance.

Singing Fingers- for iPad- a fun app that records sound and paint, and can be played by tracing the painting. Developed at MIT by the Lifelong Kindergarten Group

Works Cited- Websites/Books for Students

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Abrams, 2013. Print. This book is for students age 5 and up teaches a great lesson about success, and invention. It is important to also teach girls that there are many activities that they can relate to that are not typical.

"HowStuffWorks "Entertainment"." *HowStuffWorks*. N.p., n.d. Web. 30 June 2014.

<<http://entertainment.howstuffworks.com>>. This website provides answers to queries by typing in a topic to search such as circuits or arduinos. It is a great resource for kids who are curious and want to know how things work.

Hunt, Emily M., and Michelle Pantoya. *Designing dandelions*. Lubbock: Texas Tech University Press, 2013. Print. Written by an engineer herself, this book was written to interest kids, especially girls in the STEM sciences. It was written with literacy experts to appeal to a young audience and to show kids about

discovering life and problem solving.

"MaKey MaKey | Buy Direct (Official Site)." *MaKey MaKey (Official Site)*. N.p., n.d.

Web. 30 June 2014. <<http://www.makeymakey.com/>>. This website teaches kids how to use their imaginations to invent things using the kit and a computer. According to the site, MaKey MaKey is an invention kit for the 21st century.

"Museum of Science, Boston." *InventorsToolbox: The Elements of Machines*. N.p., n.d.

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<<http://legacy.mos.org/sln/Leonardo/InventorsToolbox.html>>. This is a great site for kids interested in inventing things using simple machine concepts.

"Rube Goldberg: Home of the Official Rube Goldberg Machine Contests." *Rube*

Goldberg. N.p., n.d. Web. 30 June 2014. <<http://www.rubegoldberg.com>>. The site is a great resource in teaching kids about inventions, particularly complicated inventions that perform simple tasks. It brings fun to science.

"We Make Learning to Code Fun and Easy." *Tynker*. N.p., n.d. Web. 30 June 2014.

<<http://www.tynker.com/>>. This site provides opportunities for kids to create their own games, animated stories, and projects, and to publish their apps for the web. It also allows kids to play games other kids have designed using this site. It is most appropriate for students, ages 6 and up.

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Bibliography for Teachers

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<<http://makezine.com/projects/drawdio-musical-pencil/>>. This website has directions and a different version of how to build the pencil, and a great diagram of the actual circuit you need to build.

"7 Apps for Teaching Children Coding Skills." *Edutopia*. N.p., n.d. Web. 30 June 2014.

<<http://www.edutopia.org/blog/7-apps-teaching-children-coding-anna-adam>>. This site is an educational resource that provides reviews and links on new apps for mobile devices, scholarly articles and current trends. The article reviews apps that teach coding to children from young ages and up.

"A Rough Guide to Electronics." *A Rough Guide to Electronics*. N.p., n.d. Web. 30 June

2014. <<http://www.madlab.org/electrnx/electrnx.html>>. This is a great website from Australia that teaches the basics of electronics to the beginner. It is geared toward good readers in the early grades and students in grades 4 and up.

"AnnMarie Thomas." *TED: Ideas worth spreading*. N.p., n.d. Web. 30 June 2014.

<http://www.ted.com/speakers/annmarie_thomas>. This is the second TED talk that inspired me to incorporate play into my unit on bringing Science, Technology, Engineering and Mathematics to the young child. Who wouldn't want to light up LED's with play dough?

"Computer programming." *Khan Academy*. N.p., n.d. Web. 30 June 2014.

<<http://www.khanacademy.org/cs/browse-programs/>>. This site contains examples of games that students have designed with coding resources, and can be played online.

"Drawdio!" *Instructables.com*. N.p., n.d. Web. 30 June 2014.

<<http://www.instructables.com/id/Drawdio/>>. This site provides written instructions that are downloadable, and photographs as well as videos of the circuits and pencil.

"Hack a banana, make a keyboard!" *Jay Silver*: N.p., n.d. Web. 30 June 2014.

<http://www.ted.com/talks/jay_silver_hack_a_banana_make_a_keyboard.html>. The incredible video inspired me to write this curriculum unit based on play. Jay Silver knows how to capture his audience, both in his descriptions and enthusiasm to bring joy into discovery of the world around us.

"K-12 Robotics." *K-12 Robotics*. N.p., n.d. Web. 30 June 2014.

<<http://www.robotics.usc.edu/interaction/k-12/index.php/>>. This site provides high caliber lesson plans, curricular materials and resources for teaching robotics to K-12 but with an emphasis on Grades 5 through 8. The resources are very useful for teachers in the sciences, math and technology.

"Learn." *Code.org*. N.p., n.d. Web. 30 June 2014. <<http://code.org/learn>>. This site was developed to interest more kids in coding and the STEM fields, especially girls and students of color. It offers tutorials for kids aged 6-106 to learn how to code and offers advanced activities as well. It is one of the best sites I have used in the classroom setting and students also enjoy the games.

"Lifelong Kindergarten: Homepage." *Lifelong Kindergarten: Homepage*. N.p., n.d. Web. 30 June 2014. <<http://llk.media.mit.edu>>. Their website says it best- "We develop new technologies that, in the spirit of the blocks and finger paint of kindergarten, expand the range of what people can design, create, and learn. This

group is responsible for so many extraordinary applications and inventions to encourage kids to creatively solve problems in the STEM subjects.

"MIT Media Lab." *MIT Media Lab*. N.p., n.d. Web. 30 June 2014.

<<http://web.media.mit.edu/>>. As the website states in the best words, "Imagine you could draw musical instruments on normal paper with any pencil (cheap circuit thumb-tacked on) and then play them with your finger. The Drawdio circuit-craft lets you "MacGyver" your everyday objects into musical instruments: paintbrushes, macaroni, trees, grandpa, even the kitchen sink... "

"MaKey MaKey | Buy Direct (Official Site)." *MaKey MaKey (Official Site)*. N.p., n.d.

Web. 30 June 2014. <<http://www.makeymakey.com>>. This site has great ideas to encourage people to use their imaginations in inventing new ways to do old things with the Makey Makey kit. The Maker movement is a great way to teach kids to think outside the box and develop critical thinking skills.

"MadLab Electronic Kits." *MadLab Electronic Kits*. N.p., n.d. Web. 30 June 2014.

<<http://www.madlab.org/kits.html>>. This site offers electronic kits for sale as well as resources for kids to use, and teachers to understand. It has resources for the do-it-yourselfer from hard to find electronics to online tutorials and links. It is great for the self motivated child or teacher in search of many hours of fun on the internet. I found many links, which exponentially grew to offer so many more avenues.

McGonigal, Jane. "Gamifying Student Engagement." *Edutopia*. N.p., n.d. Web. 10 Mar.

2014. <<http://www.edutopia.org/blog/gamifying-student-engagement-matthew-farber->>>. This TED talk advocates using gaming to increase student engagement

in various content areas. She argues in favor of using gaming in the classroom for problem solving and other real world skills that are necessary for success.

"Misunderstood Minds." *PBS*. PBS, n.d. Web. 30 June 2014.

<<http://www.pbs.org/wgbh/misunderstoodminds/mathdiffs.html>>. This article shows why kids need math, how it will affect them and other parts of their lives and how you can help them. As a teacher of other subjects, it helped me understand how math affects their lives.

"Science - Circuits and Electricity Teaching Ideas." *Science - Circuits and Electricity Teaching Ideas*. N.p., n.d. Web. 30 June 2014.

<http://www.teachingideas.co.uk/science/contents_circuits.htm>. This website provides excellent links to experiments and worksheets to teach the basics in electronics and engineering to students in grades 3 and up.

Tavangar, Homa. "How Fourth Graders Are Achieving World Peace." *Edutopia*. N.p., n.d. Web. 30 June 2014. <<http://www.edutopia.org/blog/4th-graders-achieving-world-peace-homa-tavangar>>. The TED Talk is about John Hunter and the World Peace game. This incredible project shows in a large scale how games can teach a child real world skills. This video is powerful and was done with students in elementary school but can be adapted for grades 4 and up.

"Teachers Love the Video Game Minecraft. But It's Taking Over My House." *Slate Magazine*. N.p., n.d. Web. 30 June 2014.

<http://www.slate.com/articles/technology/future_tense/2012/08/minecraft_teachers_love_the_game_but_as_a_parent_i_m_worried_my_kids_are_addicted.html>. This article explains to parents, the value of using gaming, especially

Minecraft, in the classroom, and how to balance the use of the computer game with real world activities. It will benefit teachers who battle the idea of introducing gaming to motivate their students.

"The Engineering Place (K-20 Outreach)." *Elementary and Middle School Lesson Plans, NC State University*. N.p., n.d. Web. 30 June 2014.

<<http://www.engr.ncsu.edu/theengineeringplace/educators/k8plans.php>>. There are lesson plans provided to teach kids about how machines work as well as how to make batteries. There are a limited number of plans but they are relevant to needs of this unit.

"Tutorials." - *Learn.SFE*. SparkFun, n.d. Web. 10 Mar. 2014.

<<https://learn.sparkfun.com/tutorials>>. Sparkfun offers tutorials for beginners in electronics fun, as well as sells products such as the Makey Makey kit by Jay Silver.

"We Make Learning to Code Fun and Easy." *Tynker*. N.p., n.d. Web. 30 June 2014.

<<https://www.tynker.com/>>. This site provides coding games for students as well as the chance to design their own games. Games are for ages 5-12. It appeals to students most in Grades 2-6.

"eGFI " Dream Up the Future." *eGFI " Dream Up the Future*. N.p., n.d. Web. 30 June 2014. <<http://www.egfi-k12.org/#/cards/computer>>. This website provides teachers fantastic lesson plans, activities and links to all types of interdisciplinary resources for math and science and the vast field of engineering. This is one of the best sites I found for teachers. Lessons are divided by age group and are listed for Kindergarten through Grade 12.