

Teaching Math Using Electronics

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Overview:

Students of today need to become life-long learners and it begins in the classroom. Students should understand math in real life applications. Mathematics is a crucial element for students to learn in the elementary grades. Math and science is considered to be a universal language world- wide because it is the same in all countries. A professor from East Tennessee State University, named Rick Norwood states, “ Mathematics is important to many jobs, many problems can only be solved by using mathematics, and we need to learn mathematics to understand science. The most important reason for learning mathematics, not just by rote but with real understanding, is that it trains us to think clearly and arrive at answers not just for today, but for all time.”

() Teaching mathematics helps students to not just become “good” in school, but it allows them the opportunity to build skills that will help them become a problem solver both in and out of the classroom.

STEM is a curriculum that is based solely on four disciplines. Those disciplines are science, technology, engineering, and mathematics. STEM allows an integrated learning environment that allows students to apply what they are learning in science, technology, engineering, and mathematics to real life applications. Although some of these subjects sound as though it is only aimed towards higher education, we can in fact start these teaching as early as elementary school. Researchers believe that by integrating all four of these disciplines together and have students apply what they are learning to their

everyday life, students will be engaged and learn interactively and hopefully be more interested in seeking jobs in the future that are based around STEM.

In this curriculum unit, we are combining math and science in the form of electronics. Taking this approach will allow students to interactively apply math skills in real life situations with concepts that they are familiar with. Students will collaborate with fellow students and gain independent knowledge of algebraic equations, conversions, and the way circuits work.

Rationale:

The concept of technology is constantly changing and expanding. The young minds of today are surrounded by these new inventions and have found ways to navigate through our “techy” society. Students are mesmerized by the technology, whether it is the smart phones, the high definition television sets, the clear sound systems, or the realistic and interactive toys, such as Xbox and Wii. With this being said, as a teacher, it is imperative to find ways to engage students while teaching the common core curriculum.

Educational researchers have concluded that active engagement in learning is an important tool to improve students’ comprehension. In this unit, my goal is to teach algebraic equations, conversions, and the scientific method using modern day technology and the explanation of how they work. By the end of this unit, students will be able to create their own toy/ robot using mathematical equations and the scientific method.

Objectives:

This unit is intended for students in Grade 6. This sixth grade is an inclusion classroom with 22 students. The students cycle once in the first half of the day. One sixth grade teacher teaches literacy and science, while I teach social studies and math. The students have a 45 minute lunch, along with a 45 minute rep in the afternoon. (Preps include music, computer, gym, and SAM- School Academic Music Program).

The Objectives of the unit will include the following:

- SWBAT identify the variable in an equation IOT make the equation true.
- SWBAT solve variable equations IOT identify the value of the variable.
- SWBAT define the independent and dependent variables in an experiment IOT identify a hypothesis.
- SWBAT explain how the variable changed the outcomes of the experiment IOT journal the outcomes.
- SWBAT analyze the results from an experiment IOT prove whether or not their hypothesis was correct.
- SWBAT gather and read informational text and data from the experiment.

This unit will take approximately two weeks. The activities are intended to be cross-curricula, including mathematics and science.

Background:

Math Definitions

Found in Webster's Dictionary

- (1.) Algebra- a generalization of arithmetic in which letters representing numbers are combined according to the rules of arithmetic, logic concerned with the properties of relationships of abstract entities manipulated in symbolic form. (Webster)
- (2.) Algebraic Equations- an equation obtained by equating to zero a sum of a finite number of terms each one of which is a product of positive integral powers (including the zero power) of the variables.
- (3.) Conversions- a change in the form of a measurement, different units, without a change in the size or amount.
- (4.) Inverse Operation- opposite operations that undo each other. Addition and subtraction are inverse operations. Multiplication and division are inverse operations.
- (5.) Variable- a quantity that may assume any one of a set of values, a value represented by a symbol like "x" (Webster)

Science Definitions

Found in Webster's Dictionary

- (1.) Battery- a container consisting of one or more cells, in which chemical energy is converted into electricity and used as a source of power.
- (2.) Circuits- the complete path of an electric current including usually the source of electric energy
- (3.) Conductor- a material or device that conducts or transmits heat, electricity, or sound
- (4.) Current- the time rate of flow of electric charge, in the direction that a positive moving charge would take and having magnitude equal to the quantity of charge per unit time: measured in amperes.
- (5.) Diode- is a specialized electronic component with two electrodes called the *anode* and the *cathode*. The fundamental property of a diode is its tendency to conduct electric current in only one direction.

(6.) Electricity- a form of energy that is carried through wires and is used to operate machines, lights, etc.

(7.) Inductor- Also called inductance. *Electricity*. a coil used to introduce inductance into an electric circuit.

(8.) Voltage- the amount of potential energy between two points on a circuit. (Spark Fun)

Teaching Mathematics and Science

Mathematics and science are very important subjects for students to learn. Both are considered to be a universal language. Recently, there has been a huge push for what is known as STEM education. STEM is an acronym that stands for science, technology, engineering, and mathematics. Our education system has done many studies on the importance of incorporating STEM in every classroom. Evidence has shown that STEM affects nearly every aspect of life. “In the United States, STEM is of the utmost importance because of the role these subjects play at multiple levels of society, and the tremendous impact they have.” (STEM Education) The way our economy is set up, the main focus is centered in mathematics, whether it is accounting or creating algorithms for gaming systems.

Teaching mathematics allows students to practice how to investigate and solve problems. Much of math can be translated into real life situations and is used in everyday life. Practicing mathematics stimulates parts of the brain that other subjects can't always reach. When practicing math, one uses problem-solving skills that taps in to our prior knowledge. Students not only practice math through rote memorization, but now they are told to comprehend the process of solving problems, which in return allows students the ability to apply these skills to different situations with related issues.

The subjects of science and math have always been looked at as very similar with relative concepts, such as equations and solving for solutions. But mathematics and science are more alike than just numbers and operations. Students learn the skills and organizational techniques to collect and interpret data. Students will be able to estimate and use spatial reasoning for real life situations. Students will be able to develop skills to hypothesize and solve problems to solve solutions.

The future is in our students' hands. It is imperative that we incorporate STEM as an integral part of our education system because these are the areas of study that have the most potential for job growth now and in the future. Teaching students these skills at a younger age not only sparks their interests, but gives them a strong foundation of the skills that are needed in order to be successful architects, chemists, environmentalists, engineers, and so many more.

Teaching Circuits

Circuits can be found almost anywhere in our modern society. Circuits are found in our television sets, our game systems, our vehicles, and in almost every aspect of our homes. Circuits allow us to use these devices for a specific purpose through the use of electricity. “A circuit is a closed loop, like a circle, that allows electrons, which is an electrical current, to flow through.” (*What is a circuit*) A circuit needs to be circular in shape in order to work. The flowing of these electrons are contingent upon the material it is connected to. The word “conductor” refers to most metals. Most metals allow electrons to flow through easily and transfer the electrical current, or electrons from one object to another. In order to create a circuit, there are three major components.

The first component is a source that can supply the energy, which is called voltage. Voltage is the amount of potential energy between two points on a circle. (*What is a Circuit*) Batteries are the most common example of the power source that supplies the voltage to the circuit. The battery will actually give the force to make the electrons to move through the circuit. If you look at different kinds of batteries, you will see that each is labeled with their exact voltage amount. The battery will have a positive end and a negative end. Electrons, which have a negative charge, want to flow through the negative end of the battery in order to reach the positive end. Eventually, the electrons will get to their intended location like a light bulb, laptop, microwave, etc., and give it the power to actually work.

The second component of a circuit is the called the “load”. Load in this case is referring to the actual object that you are trying to make work such as the light bulb or television. The load is what is using the voltage from the power supply to convert into the specific function that is needed, such as light, sound, etc. The electrons pass flow through the load and then leave, but this is in a continuous path, which allows it to keep working. (*What is a current*) If the power supply and energy are no longer working, then the electrons are no longer moving, which means the “load” will no longer function.

Lastly, a circuit must contain a continuous, almost circular path of conductive material. The conductive material such as a wire, needs to be connected to both the power source and the load. This makes the necessary circle needed for the electrons to flow in and out easily. The conductor literally carries the electrical current to various parts of an electrical system so that it can perform its intended function.

There are two kinds of circuits, open and closed. An open circuit means that there is a break in the conductor and the electrons cannot pass to the “load” to make it function. A closed circuit means that the conductor is a continuous path from the power supply to the “load” and back again so that it is constantly flowing in and out. Open circuits are used for items that can be turned on and off, such as lights, televisions, laptops, etc.

When the switch is on off, there is a gap in the circuit. Simply saying that the electrons have nowhere to go. When the switch is on, the circuit closes the gap so that the electrons can flow through easily and make the electronic device work.

Standards:

The School District of Philadelphia curriculum is aligned to the Pennsylvania Academic Standards for science and mathematics. This curriculum unit will include standards from science along with standards from mathematics, which will focus on algebraic equations and expressions. Students will focus on the many steps on how to experiment. They will be able to articulate their hypothesis and understand the difference of an independent variable and dependent variable.

Science

CC.3.5.6-8.C: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CC.3.5.6-8.D: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

CC.3.5.6-8.G: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

S6.A.2.1: Apply knowledge of scientific investigation or technological design in different extents to make inferences to solve problems.

S6.A.3.2: Apply knowledge of models to make predictions, draw inferences, or explain technological concepts.

S6.A.3.1: Explain the parts of a simple system, their roles, and their relationship to the system as a whole.

Math

M06.B-E.1.1.2: Write algebraic expressions from verbal descriptions. Example: Express the description “five less than twice a number” as $2y - 5$.

M06.B-E.1.1.4: Evaluate expressions at specific values of their variables, including expressions that arise from formulas used in real-world problems. Example: Evaluate the expression $b^2 - 5$ when $b = 4$.

M06.B-E.1.1.5: Apply the properties of operations to generate equivalent expressions. Example 1: Apply the distributive property to the expression $3(2 + x)$ to produce the equivalent expression $6 + 3x$. Example 2: Apply the distributive property to the expression $24x + 18y$ to produce the equivalent expression $6(4x + 3y)$. Example 3: Apply properties of operations to $y + y + y$ to produce the equivalent expression $3y$.

M06.B-E.2.1.1: Use substitution to determine whether a given number in a specified set makes an equation or inequality true.

M06.B-E.2.1.2: Write algebraic expressions to represent real-world or mathematical problems.

M06.B-E.3.1.1: Write an equation to express the relationship between the dependent and independent variables. Example: In a problem involving motion at a constant speed of 65 units, write the equation $d = 65t$ to represent the relationship between distance and time.

M6.B.2.1: Choose or use appropriate tools and/or units to determine measurements within the same system.

M6.E.1.1.2: Choose the appropriate representation for a specific set of data (choices should be the same type of graph).

Strategies:

This unit will contain age- appropriate activities that will be included cross- curricular in both science and mathematics. Lessons will be differentiated to meet IEP learning goals and reach every student. Students will access a wide variety of sources, including web, text, and videos in order for students to get a deeper understanding of experiments and real life applications of mathematics using algebraic expressions and equations. Students will do research and hands-on activities in order to engage students and reach the many different type of learners within the classroom.

Some strategies I plan on incorporating are the following:

Journaling

Within this three- week curriculum unit, students will engage in journaling. At the beginning of every science class, students will be given a symbol or a question about electronics. Each journal includes a brief and general description, along with prompts and questions to help guide the students in creating their own thoughts and hypotheses.

The students will be given five to ten minutes to write freely in response to the prompt.

This strategy allows students to integrate their prior knowledge, as well as the knowledge the students have attained in the classroom. Journaling helps document the students' growth throughout the curriculum unit and it will allow students to record questions or interesting facts. Setting this activity at the beginning of each lesson ensures that the students are reflecting and focusing on the topic at hand, so that they are ready for the lesson ahead.

Choice Boards

One of my main objectives as a teacher is to encourage and guide students to become independent learners. Students need to take ownership of their learning process and the activities they complete. Choice boards are an excellent strategy, which gives the students an active role in their learning by giving the student options. For a choice board, the teacher first has to determine the objective. Once the objective and purpose have been established, the teacher will choose activities, which help reach the outcome of the designated objective. There should be a wide variety of activities that will inspire the

many different types of learners within the classroom. The choices will then be visually represented to the students, whether in words, or by examples. Students will then be given the direction to choose one, or more than one activity that is engaging to their needs. With this strategy, it allows students to choose a project or activity that they are interested in, which will result in a better product and comprehension.

Differentiation

In a classroom there are many types of learners. Each student comes to class with different cultural backgrounds, academic backgrounds, interests, learning styles, etc. It is important to differentiate the content, instruction, and student products in order to ensure the success of all students. Differentiation is the matching of appropriately challenging curriculum and instruction with a student's ability, interests, and learning styles through a variety of activities, strategies, and material ("Differentiation"). In this curriculum unit, all students will be learning the same content, but each student's needs will be addressed throughout the unit. Students will show their understanding in a variety of ways that is personal to their needs. Lessons will ensure to challenge students through tiered activities and higher order questioning. With planning, differentiation will help each child accelerate as a life- long learner, while reaching the goal of each objective for the unit.

Chronological Sequencing

In mathematics and science it is imperative that students understand the concept of following directions in sequential order. When solving algebraic equations and experimenting, if a step is missed or in the wrong order, the outcome will be different. In this unit, students will have to create directions in order to create a circuit that lights a LED bulb when they have the correct answer. Having the students write and follow the directions that they have created will ensure me that they understand how the circuit works.

Experiments

Experiments can be used either to introduce new ideas or to clarify puzzling aspects of topics with which students typically struggle. If the result of an experiment is surprising yet convincing, students are in the position to build ownership of the new idea and use it to scaffold learning. In addition to checking that the conceptual focus of the experiment has been understood correctly, assessments can push students to describe a follow-up experiment or to extend the concept to another application (Pedagogy in Action).

Experiments allow for active and collaborative learning in the classroom. Students learn by doing.

Think Pair Share

The Think-Pair-Share strategy is designed to differentiate instruction by providing students time for creating their own thoughts and conclusions about a topic. It allows time for students to formulate questions or findings that might have. After students were

given a few minutes to independently think, then they turn to their partner/buddy and share their thoughts. The partners have a meaningful discussion where they are being active learners. “This learning strategy promotes classroom participation by encouraging a high degree of pupil response, rather than using a basic recitation method in which a teacher poses a question and one student offers a response.” (Read Write Think) Having students work with only one partner rather than whole class or group instruction, the students have more of a voice. They are heard by their partner and are able to have a continuous and fluent conversation. Being able to have this personal conversation about what they are thinking which increases their sense of involvement in classroom learning. During this time, the teacher is able to circulate around the room, join in on conversations, answer questions, or just observe.

Centers

Centers are areas in the classroom where students refine a skill or extend a concept. It allows students to explore, practice, and apply skills both independently and collaboratively in an engaging way. Incorporated within each center is a variety of multiple intelligences, which allows each student the opportunity to learn the same skill in different ways. Students are held to a high standard during centers and students are aware of the routines and how the material is being assessed. During centers, the teacher has the ability to walk around the classroom and assess each student’s needs on an individual level. It allows time for those students who are struggling to work with a buddy or the teacher in order to feel more confident with the skill. Other students may need to have enrichment materials to help them keep excelling.

Classroom Activities:

Lesson 1: Teaching students how to investigate like a scientist/engineer

Time: 45 minutes per day/ 1 day

Objectives:

Students will be able to identify and observe technology around them IOT formulate questions about their functions and how they work.

Materials:

- Laptop
- Worksheet (Appendix A)
- Definition of “robot”
- Journal

Procedures:

1. Introduce the idea of technology to students. Allow a conversation about what they think technology is.

2. Students will complete a journal entry on what they think a robot is. Allow students time to share through “think-pair-share” with students around them so that they can compare their different definitions.
3. Show students the actual definition of what a robot is. “Robot- a mechanical device that is capable of performing a variety of tasks on command or according to instructions programmed in advance.”
4. Have students compare and contrast their own personal definitions with the actual definition and their misconceptions of the term “robot”.
5. Now that students have a better understanding of what a robot is, allow them the opportunity to look around in their daily routine and identify what is a robot and what is their function. Students will complete these observations on the worksheet, which can be found in the Appendix.

Lesson 2: Understanding a circuit

Time: 45 minutes/ 2 days

Objectives:

Day 1:

Day 2:

Materials:

- Graphic organizer
- Erasers or Pencil (1 for each student)
- Journal
- Video (<https://www.youtube.com/watch?v=VnnpLaKsqGU>)
- Exit Ticket
- Computers (<http://www.andythelwell.com/blobz/guide.html>)

Procedure:

Day 1

1. Have students look refer back to their worksheet on what a robot is and where they see them. Create a class discussion about what they think makes those robots work.
2. After students come to the conclusion that electricity is what allows the robot to complete its intended function, make a graphic organizer with word electricity in the middle. Find out what students already know about electricity. Ask:
 - What is electricity?
 - What is electrical current?
 - What is an electric circuit?

Have them draw examples of electricity and electric circuits in their lives. Place their answers in the graphic organizer, so that they can refer back to.

3. Show video clip of the details on how a circuit works.

(<https://www.youtube.com/watch?v=VnnpLaKsqGU>) Tell students that they cannot see electricity because electrons, the charged particles whose movement through a substance

creates electricity, are too small to be seen even with a microscope. When electrons flow through certain substances (like copper wire), they form an electrical current. Electrical current provides energy to power all kinds of things, from video games to refrigerators to cars! (“The Blobz guide to electrical circuits”)

4. Journaling- Have students jot down in their journal something they already knew about circuits, something they learned about circuits, and something they want to know about circuits.

Day 2

1. In order for students to get a better understanding, have the students act out an electrical circuit.

- Students should form a circle. Tell students that our classroom represents a battery and they represent a wire conductor. The circle represents a circuit.
 - Discuss the term battery. There is a positive and negative end.
 - Their right hand will be the positive end. Their left hand will be the negative end.
- Give every student in the circle the same object. An eraser or pencil will be the easiest way to ensure that everyone has the same item. Tell students that these eraser/pencils represent electrons inside a wire conductor. Explain that a wire conductor is full of electrons.
- Pass your "electron" to the student on your right. The student receiving your electron should in turn pass the one he or she is holding to the right. Have students continue passing on electrons to the person to their right. Tell students that because electrons share the same negative charge, they repel one another, which keeps them moving along in the same direction. State again that the flow of electrons through a conductor is called electrical current.

2. Now tell two students to separate more than arms- length apart. Tell them to pass the eraser/pencil to the left again. Allot time for them to figure out what happened this time around. What made it different? The current stopped.

- This is the perfect time to introduce the concept of “open” and “closed circuits”.
 - Which one do you think was a closed circuit?
 - Which one was an open circuit?
 - Do you think our computers are open or closed circuit?

3. Students can use computers to get a better understanding of circuits on The Blobz Guide to Electronic Circuits. (<http://www.andythelwell.com/blobz/guide.html>)

4. Journaling- Have students write down what their thoughts of this hands-on activity. Did this help them have a better understanding of how a circuit works? What did you notice when we were passing pencils/ erasers?

5. Exit Ticket-What is a circuit? (Can be written as a definition or as an example.)

Lesson 3: Using a circuit to create a “cockroach” race (working with conversions)

Time: 45 minute/ 2 days

Objectives:

Day 1: Students will be able to use their knowledge of circuits in order to create a moving robot that we will call a cockroach.

Day 2: Students will be able to race their own cockroach in order to measure the distances in various forms of measurements.

Materials:

- Toothbrushes (1 per 2 students)
- AAA Battery (1 per 2 students)
- Wire
- Phone vibrator
- Wire cutters
- Packaging tape
- Yard stick
- Measuring tape
- Rulers
- Worksheet (Appendix C)
- Directions (Appendix B)
- Journal

Procedures

Day 1:

1. Put the students in partners.
2. Cut the top of the toothbrush from the handle.
3. Review the concept of a circuit.
4. Show the students an example of the finished product, which we will call a cockroach.
5. Give each pair of students a direction sheet, which walk the students step- by- step with how to create their own cockroach. Review the directions as a whole class and create a cockroach while following the directions. Be sure to allot time for any questions or concerns.
6. Distribute the toothbrush heads, AAA battery, wires (pre-cut), and cell phone vibrator to each group.
7. Allow students time build their cockroach. Make sure to be available to help those who are struggling with the directions.
8. Students can walk around and observe the other cockroaches that their classmates have built.
9. Have students create a hypothesis of how they think their cockroach will compete in tomorrow's race. They can place this in their journal.
10. Journaling- Students can write down their thoughts about creating a cockroach. Was it difficult? Easy?

Day 2:

1. Students will review what they have been learning in math, which is converting measurements.
2. Students will share their hypotheses about which cockroach will move the farthest distance.
3. Share directions of how the race will work.
 - Set- up a track for the race. Along the track, place measuring tape.
 - Each pair of students will have to name their cockroach.
 - Each pair of students will be given 1 minute to allow their cockroach to race on the track. The other students will be observing each cockroach.
 - After the minute is up, they will have to record how far their cockroach has gone in yards, feet, and inches.
 - Students will use the worksheet to jot down their observations and how far each cockroach went in inches.
4. Once all the students have raced their cockroach and all the information has been recorded on the worksheet, students will then begin converting their measurements to centimeters, millimeters, and if possible yards and feet.
5. Review the conversions and collect worksheet.
6. Create an awards ceremony for gold, silver, and bronze.
7. Allot time for students to journal what they thought of the experiment/race. Was their hypothesis correct?

Lesson 4: Creating circuits as a math center

Time: 30 minutes per day/ 5 days

Objectives:

Students will be able to create a circuit using cardboard, wires, and screws IOT practice finding the value of a the given variable.

Materials:

- Cardboard
- Battery Pack
- Screws
- Wire
- Bolts
- Light Emitting Diode
- Calculator
- Markers

Procedure:

Day 1:

Students will create their own circuit board that is going to be turned into a review center for algebraic equations. At the beginning, set students up in partners and show them an example of a finished circuit board, so that know what they will be creating. Review what makes a circuit.

1. Distribute cardboard to each pair of students.
2. Students need to create their own variable equations. They will then solve each equation to solve for the given variable.
3. Have students choose one side of the cardboard to list 5 variable equations and the other side will list what each variable equals.
4. Next to each variable equation (on the one side of the cardboard) poke a screw through the cardboard. On the back, place the bolt on the screw.
5. Do this same step for each variable equation and on the other side where the variables and what they equal are listed.
6. Once all the screws and bolts are set in place, take the light emitting diode and place in the middle of the top of the cardboard.
7. Now wrap a separate wire around each bolt, on the back of the cardboard and attach to the light emitting diode at the top.
8. Attach a battery pack to the back of the cardboard with packaging tape and connect those wires to the light emitting diode as well.
9. When all the wires are attached, connect the alligator clips to the light emitting diode. (The alligator clips are what you are going to connect to the screws of the matching variable and variable equation. When you connect the right pair, the light emitting diode will light up because it is a complete circuit.)

Day 2-5

The students' final projects will now serve as a math center for the rest of the week. Students that are in that center will work on solving variable equations.

Annotated Bibliography

"42 STEM iPad Apps for Kids (Science, Technology, Engineering, Math)." *Imagination Soup.*, 22 May 2012. Web. 24 Feb. 2015.

- Provides various games and applications that are centered around STEM.

"The Blobz Guide to Electric Circuits." *The Blobz Guide to Electric Circuits.* Homeschooler Cafe, Web. 24 Feb. 2015.

- This website is a site for students to be able to go on and explore. They can play games, watch clips, and practice how to create circuits and the differences between open and closed circuits.

"Design Briefs Children's Engineering Free Resources." *Design Briefs Children's Engineering Free Resources.* Web. 24 Feb. 2015.

- This is a great resource for teachers to get different ideas for engineering and better understand different concepts. Website was created for educators.

"Engineering for the Red Planet." *Engineering for the Red Planet.* PBS Learning Media, Web. 23 Feb. 2015.

- A video that shows a professional engineer and the questions she asks every day.

"Explaining an Electrical Circuit." YouTube. YouTube. Web. 11 June 2015.

- Students will be able to watch this video to better understand and visualize how a circuit works.

"Expressions and Equations in the Real World." *Teaching Channel.* Web. 24 Feb. 2015.

- This is a video that shows how students use expressions and equations in real world situations. It shows examples of questions that students might encounter when working with expressions and equations.

Faisal, Akim, Dr. Vikram Kapila, and Dr. Maged Iskander. "Using Robotics to Promote Learning in Elementary Grades." *American Society for Engineering Education* (2012): Web. 17 Feb. 2015.

- Discusses the benefits of incorporating the concept of engineering in the elementary grades. Gives evidence that by having students build robots through hands-on experience they are setting themselves up for better success in the future.

"Lego Robots." *LEGO Robots.* PBS Learning Media, Web. 23 Feb. 2015.

- Discusses the benefits for incorporating STEM inside the classroom. It also shares how they set up their experiments for creating robots, so was helpful with how to go about creating robots with my family.

"PBS LearningMedia." *What Is a Robot?* PBS, Web. 22 Feb. 2015.

- Helps students better understand what a robot is, for example a vending machine. Models how to identify robots and their function. Introduces the concept of circuits and electricity.

"Robot Activities - Fun Lesson Plan for Kids, Robotics Classroom Teaching." *Robot Activities - Fun Lesson Plan for Kids, Robotics Classroom Teaching*. Science Kids, Web. 23 Feb. 2015.

- Gives lesson plans for incorporating robots in the classroom.

"Standards- Mathematics." *Pennsylvania Department of Education*. Student Aligned System. Web. 23. Feb. 2015.

- Used these standards to help align my lessons and activities to the 6th grade practices.

"Standards - Science and Technical Subjects." *Pennsylvania Department of Education*. Student Aligned System, n.d. Web. 23 Feb. 2015.

-Used these standards to help align my lessons and activities to the 6th grade practices.

"STEM Education." *Teachcom*. Web. 9 June 2015.

- Discusses the importance of teaching science, technology, engineering, and mathematics in the classroom. Gives evidence of why it is important now and for the future.

"What Is a Circuit?" *What Is a Circuit?* Web. 11 June 2015.

-Helped teach me how to better understanding the properties of a circuit.

"What Is an Electric Circuit?" *What Is an Electric Circuit?* Web. 11 June 2015.

- Gives background knowledge of the three components a circuit needs, which is the power supply, the load, and the conductor.

Appendix B

Directions to Build a Cockroach

1. Make sure you have all of your supplies.

- Toothbrush head
- AAA battery
- Wires
- Cell phone vibrator
- Packaging tape

2. Attach AAA battery to the center of the top of the toothbrush head. (Use glue or double sided tape.)



3. Attach the phone vibrator to the battery.



4. Connect one wire to the positive end of the battery. (+)

5. Connect the other wire of the vibrator to the negative end of the battery. (-)

*When you do this, you cockroach will come alive!

