Robotics: Creating the Limitless Potential of Nanotechnology

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Overview

STEM Education is growing in demand all over the country with a renewed focus being given to the proper strategies used to reach proficiency in Science, Technology, Engineering, and Mathematics (STEM). Currently the US is lacking behind many developed and underdeveloped countries in regards to STEM education. With the potential opportunity that exist in these fields, it is critical that our students are prepared for a world that could be dependent on STEM innovations. Part of the reason the US is so far behind, is that for many years, STEM Education was seen as a low priority, particularly when compared with other disciplines. Now that the US has come to its senses, we as educators must make an asserted effort to prepare our students for the future that lay ahead. This holds particularly true regarding the fields of STEM.

To fully appreciate my methods in this unit, it is important to recognize the diversified conditions in which I work. I teach Biology and Physical Science at South Philadelphia High School. My students come from very diverse ethnic backgrounds, with the population being 57% African American, 28% Asian, 8% Latino, and 6 % Caucasian. This creates quite a dynamic in regards to which practices are utilized best in the classroom. However, while they are diverse ethnically, they are generally the same economically with 85% of them being economically disadvantaged or low income. Moreover, 30% of the school is English Language Learners (ELL). As mentioned before, presents a dynamic in the school that is both exciting and intimidating. Nonetheless, there differences can be used for good, more or less as an catalyst to reinforce similarities they already share.

There are many things I hope to accomplish with this unit, including creating awareness about the potential of the nanotechnology industry. In addition, I plan to increase their overall proficiency in the fields of STEM education. For these goals to be obtained, my students will engage in a multitude of activities that will build on each other until a robust understanding of robotics and how its fundamentally applied to nanotechnology is obtained. Furthermore, I will like my students to expand on their understanding of robotics and nanotechnology by exploring those fields outside of this unit. This could take place in robotics clubs, workshops, and online communities (blogs, social media, etc.) that offer new and unique perspectives into the fields of STEM.

My expectations will be accomplished by aligning my curriculum with several of he common core standards the School District of Philadelphia have provided. The standards will serve as a tool of guidance, facilitating the execution of each stage in the unit. It will also provide the necessary structure to keep pace with the district's scheduling and timeline. Due to the fact that I expect the duration of the unit to be 2-3 weeks, I will rely on the schedule and timeline to help with pacing. The standards will be used throughout the unit to ensure that students are achieving mastery of the content. The content of the unit will not focus on anyone of these particular standards but touch on all of them at any point throughout the unit, thus giving the students a complete understanding of the material. If executed correctly, each standard should reinforce the idea that robotics and nanotechnology will play a major role in our future. A list of standards can be found in the Appendices at the end of the unit.

Rationale

Stem education is more relevant than ever, particularly in the United States. While the US struggles to keep up with the advances in technologically related fields, the rest of the world is exceeding expectations and leaving the US behind. This is relatively new territory for the US, since leadership in the fields of technology have helped bring the US to its dominant position amongst world leaders. The renewed focus on STEM education has lead districts to provide school with additional funds to subsidize the resurgence of STEM leaders in America. With the newfound funds, amazing opportunities have sprung up in schools across the country, especially underperforming schools in urban settings. Accordingly, there is no better time to reignite our student's curiosity in STEM education, then now.

The totality of my research has galvanized my belief in STEM education. Focusing on STEM education increases students' options when entering college and the work force. It accomplishes this by developing key skills, which can contribute to a person's success. One of these skills include, "Learning by Discovery", which involve students learning from their mistakes through modification and revision of their strategies. I will use robotics as the platform to develop these skills, encouraging them to learn from the discoveries or the mistakes they make throughout the process .

Robotics

When the word robot is brought up, some people think about the fantastical human like machines that are consistently portrayed in Hollywood films. Others think of any automated machine, from an ATM to a car assembly line. All would be correct and right in line with what the originators of robotics hand in mind for their futuristic machines. The word robot was actually coined by a Czech novelist Karel Capek in a 1920 play titled, Rossum's Universal Robots (RUR). Robota in Czech is a word for worker or servant (Sobhan, 2003). Amazingly, this simple definition of a robot still applies to what we believe a robot to be, specifically, entities that can make our life easier or if nothing else less stressful.

Robotics have been critical part of the success throughout the history of the US. In fact, robotics have played a huge role in the advancement of our nation through its contributions to its factory industries, particularly automobiles. Assembly lines reinvented the way Americans manufactured products, thus giving America a significant advantage over other countries when it came the rate of production of goods.

Since the original idea of a robot was conceived, the definition of a robot has become more sophisticated, including more accurate descriptions of how a robot is used. In 1979 the Robotics Institute of America, defined a robot in the following way:

A robot is a <u>reprogrammable,</u> <u>multifunctional</u> manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks (Sobhan, 2003).

More specifically, the first industrial robot of its kind, Unimate, was created in the year 1954. It was the first programmable robot and was designed by George Devol. He coined the term Universal Automation to describe the behavior of his newly created machine (Sobhan, 2003). In 1962, this name later formed the name of the first robot company to ever exist , called Unimate. It went on to automate the manufacturing of TV picture tubes for many years (Sobhan, 2003).

As the idea and development of robotics continued to advance, people began to find broader uses for robots. People were able to recognize the potential of robotics in the business industry. Its efficiency and production levels were second to none, therefore making it possible for the use of robots to become much more popular. In 1978, the Puma (Programmable Universal Machine for Assembly) 560 Manipulator was invented. It was developed by Unimate and possessed a General Motors design support system (Sobhan, 2003). This was a seminal moment in US history since it catapulted the US to the new heights in the automotive industry, thus strengthening the economy and giving Americans a better quality of life.

In the decade to follow Robotics experienced a rapid period of growth. In the 80s many institutions began to introduce programs and courses in robotics. With all the knowledge they had gained throughout the years, robotics was now moving closer to the forefront of what we now call STEM (Science, Technology, Engineering, Mathematics) education. More emphasis was now being given to courses like mechanical engineering, electrical engineering, and computer science (Sobhan, 2003).

Presently, the field of robotics is more prevalent than it has ever been. With major emphasis being given to STEM education by local and federal governments, many more programs and organizations have formed to help support the growth of STEM education across the country. Since the 1995 invention of NASA’s Mars Exploration Rover, emerging applications of small robotics and mobile robots have driven a second rapid growth of start-up companies and research in the industry (Sobhan, 2003).

A deeper understanding of robotics had now evolved. Following the review of robotics history with my students, they will begin to identify some of the mechanical elements that make up a robot. More specifically they will focus on the sensor, controller, and actuator. As I explain the details of each element, keep in mind that robots were invented to do human work. Therefore, many mechanisms of the robot are modeled after mechanisms we find in humans. This may help student understanding in the classroom by simplifying the information and making it more relevant to things they already know.

SENSORS

When we identify what sensors human possess, the best place for us to start is the eyes. These are our one of our most important sensors, providing us with many vital pieces of data that we use for survival. Human also have other senses that we use for survival including sound, touch, taste, and smell. As mentioned before Robots model this element with its own set of sensors. They measure robot configuration/condition and its environment and send such information to robot controller as electronic signals (e.g., arm position, presence of toxic gas) Because robots are often asked to do the jobs we wont do they often need information that is beyond 5 human senses (e.g., ability to: see in the dark, detect tiny amounts of invisible radiation, measure movement that is too small or fast for the human eye to see) (Sobhan, 2003).

ACTUATOR

For us humans, our actuators consist of our appendages. They are what our brains and our muscles tell to move when we want some form of work completed. Common robotic actuators utilize combinations of different electro-mechanical devices. Consequently, we can think of an actuator as something that gets work done. If students can wrap their minds around that, it will help them remember how all the pieces come together to form a robot. Some of the different types of actuators used on robots include (Sobhan, 2003):

-Synchronous motor
-Stepper motor
-AC servo motor
-Brushless DC servo motor
-Brushed DC servo motor
-Hydraulic Motor
-Pneumatic Cylinder
-Pneumatic Motor
-DC Motor
-Servo Motor

CONTROLLER

When explaining this element of robots to students it might be helpful to compare the controller of robot to the brain of a human. Its intuitive for our students to understand how the brain processes data that it collects from its sensors (eyes, ears, etc.) So by relating these concepts to a robot, students should have an easier time understanding the function and purpose of a controller. Just like our brains, robot controllers provide necessary intelligence to control the manipulator/mobile robot. They are able to accomplish this by processing sensory information and computing the control commands for actuators to carry out specified tasks. In addition, as it is in our brains, it is critical that we are able to store information. Storing information increases our chances for survival and, for robots, increases their efficiency and productiveness. Robots use storage devices to achieve this goal: e.g., memory to store the control program and the state of the robot system obtained from the sensors. Lastly, just like we have nerves that transfer the data from the brain to the rest our bodies, robots need the same. They use what is called Interface units, which connect hardware to interface digital controller with the external world (sensors and actuators) (Sobhan, 2003).

Circuitry

As mentioned above, robots were created to perform some type of function or do some type of work. The concept of work is one that should be familiar to my students, however it can never hurt to refresh their memories and reinforce the major themes of the concept of work. Accordingly, my students will briefly review the scientific definition of work and how it relates to robots. Ideas, such as change in (delta) Work is equal to an amount force being applied over a change in distance, or more simply

$$\boldsymbol{\Delta w = F\,\Delta d}$$

It is important for my students to understand this equation. It will help them make the connection between the relationship that work shares with force and distance. The idea is that understanding the relationships in this equation will lead to a deeper understanding of how charges move. For example, the equation highlights that as charges (forces) move, they gain or lose energy (work) (Aziez, 2014). Therefore,

Δw = work done = charge in energy

The unit will not spend too much time reviewing these ideas to avoid digressing from the central theme of the unit, nonetheless it is still important enough to be addressed.

The history of Robotics is directly tied to the electricity helping it to function. In fact robotics would not exist if it were not for the electrical current that powers the mechanics of the robot, allowing it to do work. Because of its vital role in allowing robots to function, my students will spend small amount of time reviewing the fundamentals of Circuitry. To start, they will understand what an electrical charge is and what enables it to move through a system. Next, we will spend time discussing how, in circuitry terms, a system is represented as a circuit with the flow of energy starting at one point and ending at another. Following this, my students will essentially identify what an electron is and how it moves. Once this is established, they will track the movement of electrons through the circuit, which results in work being done. Hence, the electrical current is the rate of flow of charge (Aziez, 2014).

Once an adequate amount of time has been spent reviewing the previous topics, we will move on the next important theme of the unit, which is to understand the potential differences in current that exist within a circuit. They will start by identifying the definition of potential difference to be, the energy gained or lost by a unit of charge as it moves from one point to another. In terms of circuitry this can be represented by the equation:

$$\textbf{V (voltage)} = \Delta w / \Delta q \textbf{ (total charge)} \Rightarrow \textbf{volt = joule/columb}$$

This equation is related to another important idea of robotics, which is how power is generated. By identifying the relationship between total charge and work, they be able to extrapolate that power is the rate at which work is completed, or

$$P = \Delta w / \Delta t$$

After putting it all together they should conclude that the relationship, between work, power, and voltage can be explained by the following equations,

$$P = \Delta w/\Delta t \times \Delta q / \Delta q \quad \Delta w / \Delta q \times \Delta q / \Delta t = V.I \text{ (current)}$$

The last step will be to connect all of these ideas to resistance and its role in circuitry. The basic concepts they will need to know is the relationship that voltage, current, and resistance share with each other, which is explained in the following equation,

$$R = \frac{V}{I} \text{ or } V = IR$$

To help reinforce this concept, my students will be given the following list to help identify the 4 limiting factors of resistance (Aziez, 2014):

1. The length of conductor
2. Cross-Section area of conductor (A) => R @ 1 / A
3. The nature of material conductor
4. The temperature of conductor.

This will conclude our lessons on circuits and catalyze our next lessons on nanotechnology. The information from the circuits lesson, will thus be used as the foundation for what we will learn in the nanotechnology section the unit.

Nanotechnology

The central theme of this unit focuses on the concept of Nanotechnology. Nanotechnology is a rapidly growing field with a world of potential. At times some of the applications of nanotechnology can seem unrealistic or fantastical. However, with the exponential rate at which technological information grows, we could soon see applications of nanotechnology become commonplace.

I chose nanotechnology to be the central theme of the unit because of its interdisciplinary nature. It is important for my students to understand that nanotechnology is necessarily a multidisciplinary field which encompasses and draws from the knowledge of several diverse technological fields of study including chemistry, physics, molecular biology, material science, computer science, and engineering (Jones, 2005). With so much focus now being given to STEM education, and in some cases

STEAM (Science, Technology, Engineering, Arts, and Math), my students will have the opportunity to engage in a curriculum that is preparing them for the world they will soon face.   But what exactly is nanotechnology?

Nanotechnology was first thought of in 1959, by a nobel prize winner Richard Feynman, who gave a speech titled “There’s Plenty of Room and the Bottom”. It has since been defined as a description of activities at the level of atoms and molecules that have applications in the real world (Jones, 2005).   Nanotechnology can be considered many different things, however there are some common characteristics of all nanotechnology applications. It comprises technological developments on the nanometer scale, usually on the order of 0.1 to 100 nm. A nanometer is one billionth of a meter (1 nm = 10-9 m). For perspective, I will share with my students that a hydrogen atom’s diameter is on the order of an Ångström (1 Å = 0.1 nm). Thus, ten hydrogen atoms laid side by side would measure a distance of about 1 nm across (Jones, 2005).

As mentioned before, the idea of nanotechnology can sometimes seem out of this world. Truthfully, most nanotechnology concepts are still considered to be in the precompetitive stage. However, estimations of worldwide annual industrial production could exceed $1 trillion in 10-15 years, which would require about 2 million nanotechnology workers (Jones, 2005). Although artificial nanorobots do not yet exist, nature’s biological nanorobotic systems do exist and provide evidence that such systems are at least possible (Requicha, 2003). As a result, they will understand why nanorobots have for the most part been explored in the biological context of nanomedicine (Jones, 2005).

My students will be able to connect this idea with what they have already learned about the biomolecular machines that already exist in our body. Mechanical elements like flagella and motor proteins in muscles could serve as examples of “nature’s way of doing things” (Jones, 2005).   In the Biology community biomolecular motors have drawn a lot of attention because they operate at extremely high efficiencies (e.g., some near 100%), could be self-replicating, and are readily available in nature (Jones, 2005). With this knowledge, my students will be able to envision nanorobotic applications that could range from medical to environmental sensing to space and military applications. For example, nanorobots could be used to give precise drug delivery for repairing cells or to seek and destroy pathogens. Some researchers believe this would cause a paradigm shift from treatment to prevention in the medical community (Jones, 2005).   In the appendix, three examples of potential nanomanipulation techniques are identified and can be used for further exploration

Strategies

Circuitry

To begin this journey through the different facets of Robotics in Biology, students must understand the parts of the robotics that are directly related to biology. Students will start with the end in mind when, when I unveil to them the wonders and potential of the use of nanotechnology in Biology. This will also include the moral code that should be served when dealing with robotics. I will share with the students the advancements that have been made in biotechnologies and medical robotics which will lead to an exploration of nanotechnology and its uses in our world   The hope is that students will see the big picture and then use that as a reference as they learn all of the details that create the imaginative world we will discuss. The end product will represent the "what", and the details should represent the "why and how". Learning in this way should spark my student's curiosity and motivate them to explore other fields and concepts in Science.

Mystery and amazement are two characteristics that captivate students in Science. Therefore, the first stage will attempt to get students to understand the fundamentals of Circuitry. This will include an introduction to the terms, Current, Voltage, and Resistance. Following the review of those key concepts students will then discuss how the concepts are related to Light Emitting Diode (LED) technology as well as the manipulation of those ideas to produce amplification. Following that, we will cover the purpose of a battery and how it is used in different applications. Each of these concepts demonstrate the mechanisms used in robotics, which will help my students relate what they are learning to the focus of the unit.

These concepts will help illuminate many mystifying events in science. When students are presented with problems with seemingly no solution, or awestruck events that defy all logic, they tend to become intrigued. I hope to instill this type of curiosity with my students by demystifying the concepts of electricity and displaying the wonders of robotics. Progressing with this endeavor could prove to be too challenging if students do not possess a solid background in Circuitry. Thus its of the upmost importance that that is accomplished first, then students can then proceed to work back towards our starting point of nanotechnology.

Once students have learned the symbols and meanings of several circuit concepts, they will apply what they have learned using the phET simulation website. While on the website they will access the DC only circuit simulator, where they will perform different exercises to determine the difference between different circuits among other key concepts. Students will sketch the circuits they create and then identify the key parts of their circuits. This way my students will begin to understand the concepts from different perspectives. This will continue throughout the activity as my students create different types of circuits and then identify the changes they make to the circuits. Again, this reinforces the major concepts by presenting the same ideas in a different way. The more advanced students will work on an extension of the concepts by using the same simulator to investigate the difference between a parallel and series circuit. The questions that support this activity will ask my student to apply what they have learned in real life, helping them to see the significance of learning about circuits in the first place.

Amplifier

Once students have a established a solid foundation in Circuitry they will move on to understanding how to manipulate those principals do get electricity to do what they want it to do. This first step in learning how to do this will involve amplifying the current to produce a higher Voltage, while still obeying the Law of Conservation of Energy.

Students will be given a problem to solve, which encourages them to use what they have learned to predict a way to amplify energy. They will then be given resources or circuit parts to test different ways to achieve an amplification. Their observations along with analysis will be recorded and used to gauge the level of understanding and progress on the problem. Once students have exhausted their ideas for amplification, students will be introduced to a transistor. It will be explained that transistors can be used to amplify energy and are used often throughout many different forms of robotics to amplify a charge.

Moving forward, we will also discuss how amplification is a critical tool to be used in nanotechnology, tying it back to what they were introduced to when the unit began. After we have reviewed how related this lesson is to modern and future applications, we will begin to test our hypothesis and measure the effectiveness of an amplifier in different applications. At the point my students background knowledge of circuitry will come into play as they will be able to understand why the amplification occurs in the first place.

One of the most important for my students to understand will be that the original purpose of a transistor was to amplify weak electrical currents. This was done at Bell Labs in 1947. To reinforce this idea, I will start by demonstrating a weak current that students can recognize and experience. Then we will connect a circuit using wire, a 9-V battery, an LED, a resistor, and a microammeter to measure current. My students will then note what happens when they complete the circuit first by connecting the leads together (relatively large current and the LED lights), and then by holding the leads in their hands (very small current and the LED does not light). Building on what they will have observed, students will offer their ideas about what a amplifier is and how a current can be amplified. Meanwhile it will be made clear that most electronic devices run a small current that is amplified. Students will then perform the activity I will provide them on transistors to see how transistors amplify current. Following the activity, we will have a discussion to review the answers to their questions along with what they have learned from the activity. The summation of this lab should lead to an increased understanding how nanotechnology applications can become a reality.

Nanotechnology

At this point of the unit, students will have a firm if not robust understanding of the basic principles of robotics along with the different ways it can be applied. Thus, they will be able to understand the future applications of robotics and even more so predict how its use can be expanded in new and different ways. To accomplish this my students will complete a research report on the future of nanotechnology. They will be given the option to explore all the different uses of nanotechnology in Medicine and Biology. I will encourage my students to select projects that STEM students at UPenn are currently working on to assist with their own investigation. With this in mind, students will be told that with the completion of their final activity/report for this unit they will be rewarded with a field trip to the University of Penn to possibly visit the projects upon which their essays are based.

During the lesson, students will be given guidelines to help them understand the likely relevance of the project with our future society. They will be required to present on the topics and be prepared to share their findings with researchers or anyone interested in knowing more about their subject matter. Another requirement will be to include as many of the concepts learned in class as possible. That way, students will remained focused on the major themes of the unit by connecting the past to the present and the present to the future. Once this is completed students will have come full circle, ending where they began the unit. The platform for this conclusion will be a conversation about the awe-inspiring potential of nanotechnology in our future and the opportunities that will exist because of its far-reaching potential.

Objectives

My objectives for this unit will guide my students as they progress through challenges and gain clarity on the applications of robotics to Biology in conjunction with its relevance to their own lives. Like most youths, my students are faced with many different problems and challenges of being a teen. In addition, each one of these challenges has the potential to have a dramatic impact on their lives. This makes their decision-making skills a critical part of the successes they experience throughout their lives. Because of this, it is critical that my students practice problem solving skills as often as possible. This unit provides them went an ample amount of resources to be utilized throughout their journey. Their journey will be filled with failures, obstacles, and frustration. They will be taught how to handle these situations and get the most out of their abilities. This can be extremely difficult for anyone especially young adults who are just beginning to understand their identify and where they fit in the world. Accordingly, they will focus on five core objectives that will help them gain the level of mastery it will take to achieve success. These five objectives are listed as follows:

1. Create Student awareness of Technology and more specifically robotics in their life.
2. Understand the role nanotechnology, (nanobots) will play in the future
3. Students will understand the basics of robotics and apply it to the creation of their own projects
4. Gain a deeper understanding of the Scientific Process and apply it to various activities detailed throughout the unit
5. Spark their interest to pursue Robotics outside the classroom, ie Robotics Clubs

The first objective is the most basic of all of the expectations I have for this unit. If nothing else, I would like my students to take away a general awareness of the role technology plays throughout our lives. To understand this, students will have to observe many different examples and applications of how the specific technologies can be used. To support this objective students participate in discussions that have them predict future applications of the technologies. By focusing on the past, present, and future applications of such technologies students will build a robust understanding of the significance of robotics to all life on the planet. In other words students will use what they’ve learned in the unit to make predictions and assumptions about what will happen in the future, and what has happened in the past. This will lead them to discovering the different industries that utilize robotics. This may in turn help them discover an unlocked talent or passion that has been slumbering inside until of them. All of these results can be made possible by creating awareness of the concepts involved in this unit.

The next objective is more specific and focused on the future of the technologies we will discuss. Nanotechnology is an emerging field that is growing exponentially. This is because our rate of growth for technological advancements is also growing exponentially. Therefore, preparing my students for this type of world is of critical importance. By observing the similarities of past and present advancements, students will be able to understand the relevance of robotics. This will enable them to begin identifying careers that align with such technologies, helping them to discover the many career options one will have if they decided to pursue the careers in the future.

To accurately assess my students' understanding of the concepts they will have to be tested on what they know. Ultimately, this means that one of my objectives requires them to demonstrate what they know by applying the concepts in different settings. The different applications will help reinforce many of the ideas learned throughout the unit, thus proving they have a robust understanding of the concepts.

Another major focus of the unit will be to repeatedly engage my students in the scientific process. The process of science is, in my opinion, the most important lesson students can learn from high school science. Learning the process will lead them to appreciate all the hard work that's put into discoveries and the advancement of technologies. The appreciation they will gain will serve them in many different ways when engaging in future endeavors, no matter what they may be.

This is particularly true when it comes to the trial and error processes that is at the essence of science. In my experience much of the frustration or despondence that students demonstrate stems from their fear of failure. The process of science opposes or rejects that emotion because it is often because it is in failure that we realize success. Therefore, if the process is fully understood students will learn to embrace failure rather than shy away from it, for it is from failure that we learn our greatest lessons.

Despite the fact that this objective can seem far-sighted, students should be able to respect the difference this mentality can make in their immediate future, whether it be in a school, social, or professional setting. While accepting failure as a part of life may seem unnatural to most, learning and improving from these failures should feel just as natural to most, because after all, it is how we developed our sense of survival.

Classroom Activities

Lesson 1

Objectives
For this lesson, students will observe how a transistor functions in simple circuit in order to identify how currents can be controlled and changed. Furthermore, my students will understand how current can be amplified by recognizing how a small current at the input of a transistor controls a larger current at its output.

Materials

- 9-V battery and clip with leads
- breadboard
- hook-up wire
- LED
- 220-ohm resistor
- 100K-ohm resistor
- transitor
- microammeter

Pre-Class
After receiving a good amount of background knowledge on the history of transistors students will be able to answer the following writing prompt to begin the day's activity: Explain why amplification of current is significant in our world. Where do we see it applied?
My students will be given 5-7 minutes to answer the question. Following that, they will share what they wrote with the class in order to spark a classroom discussion.

Direct/Guided Instruction
I will explain that the students are going to build two simple transistor circuits, each using a single transistor. They will understand that by building theses circuits they can observe the operation of a transistor as an amplifier, just as Walter Brattain did at Bell Labs in the winter of 1947. They will be told that by creating the circuit, they will be able to use the transistor to control the brightness of a light. Next, they will be shown a model of how to construct a circuit with an amplifier and LED. During this time I will identify the key parts and relationships that are taking place in the activity. This will include identification of single transistor, an LED, a power source, and a resistance. It will also be explained that the brightness of the LED will indicate the relationship between the current going to the base of the transistor—its input—and the current flowing from the transistor's collector to the emitter—its output.

Independent Instruction

1. Students will move into groups of three or four. Next, they will assemble the circuit shown in the diagram I provide them. Next, they will match the leads on the transistor to

the diagram, by identifying the base, emitter, and collector. Students will check with me if they are unsure of the connections.

2. Next, they will complete the input circuit with the two leads, using each method listed below:

• gently squeezing the leads
• tightly squeezing the leads
• dipping the leads in water
• increasing the distance between the leads in water
• making a dark line with pencil and touching the leads to it.
• increasing the distance between the leads on the pencil streak

3. In their lab books, make a table similar to the one shown below in which to record the intensity of the light for each method. They might use terms such as dim, average, and bright, or develop a number scale with 1 = 5 very dim and 5 = 5 very bright.

Circuit completed by	Light intensity	Sound intensity
gently squeezing the leads		
tightly squeezing the leads		

1. Following that, they will copy the circuit diagram in your lab book. They will include arrows to show the direction in which the current flows through the circuit, remembering that current flow is from positive to negative. It will be finished when they label the input circuit and the output circuit of the transistor.
2. Students will then repeat one of the methods that gives a reasonably bright light. Next, they will place the microammeter in series with the input leads and record the reading. Finally, they will move the microammeter so that it is in series with the LED and record that reading.

Closing

Finally, we will close the activity by reviewing the different concepts reviewed during the activity in a class discussion. The discussion will center on the understanding the relationship an amplifier (transistor) to the current that flows through a circuit.

Homework

1. Which methods allowed the light to glow the brightest? the dimmest?
2. Which methods allowed the most current to pass through them? the least? How do you know?
3. How good an amplifier was your circuit? How much larger was the output current than the input current? Where did the "additional" current come from

Lesson 2

Fruit Power Lab

Objectives

For this lesson, students will study the characteristics of fruit batteries in order to determine the factors that influence the efficiency of the fruit battery. They will also determine which type of fruits provide the most of amount of electrical current, represented by how much their LED lights up.

Materials

Lemon
Tomato
Orange
Apple
Multimeter
Connecting Wires
Metal plate
LED Device

Pre-Class

Students will begin the class by answering the following question:
Determine how the electrodes affect the fruit battery

Direct Instruction

In preparation for the lab, my students will review, with me, some ideas about batteries and how they will be used during the lab. Particularly, they will review how batteries contain two electrodes, which typically consist of different kinds of metals, and are filled with electrolyte to produce electricity from the chemical reactions between the electrodes and the electrolyte. They will also understand that instead of chemical batteries, fruits can also be utilized to generate electricity. Fruits contain lots of juice (electrolyte) which could ionize electrodes, the ionization tendency of which depends on the kind of metals and fruits.

Independent/Guided Practice

Procedure

1. Gather all things needed for experiment.
2. Wash hands for safety.
3. Take the clock module and place fruit in the two holders.
4. Remove plastic coatings at the end of all wires with scissors.
5. Take the black cable and tie one end to the Zinc metal contact.
6. Take the blue cable and tie one end to the Zinc metal contact and the other end of the Copper metal contact.
7. Take the red cable and tie one end to the Copper metal contact.
8. Insert the metal contacts to the fruit.
9. Attach the black and red cable to the spring contacts.
10. Watch fruit generate energy to power to the LED device.

11. Repeat the steps for each type of fruit
12. Record the different levels of light produced by each fruit

Closing
To conclude the lab, students will analyze the observations and identify which fruit created the brightest light from the LED device. They will also identify the factors that played a role in the amount of power produced by each fruit (ie. Thickness of fruit, amount of contact area, etc.)

Homework
The homework assignment is to design the simplest device to light up, based on the characteristics of a fruit battery. The assignment should build on their knowledge of the fruit batteries and expand on it by applying the information in another context.

Lesson 3

Nanotechnology Research Paper

Objectives
Students will learn to rework raw information, use details and facts, and write, in order for them to take ownership of knowledge. They will also identify the details of the nanotechnology industry in order to understand the potential of future applications.

Pre Class
My students will be introduced to the project and be given the instructions as well as the rubric that will guide the process for creating the research paper.

Direct Instruction/ Guided Practice
Following the introduction, I will show my students the best strategies for acquiring research. With my guidance, they will identify where to find relevant resources, proper formatting, specific examples of nanotechnology, etc.

Independent Practice
Once I become comfortable with their understanding of the process, they will be given several days to complete as a much research as they can during class time. Additional research can also be done outside of the classroom to contribute to the research paper. To assist with the process, they will use the rubric given to them to ensure they are aligned with the expectations for the paper.

Closing
After each research lesson, my students will summarizes the notes they have collected. The summary will include an assessment of the validity and quality of the research they have discovered.

Homework
Continue towards the completion of your research paper by including research, writing, pictures, or anything else that can contribute to the completion of your paper.

Annotated Bibliography

1) **A Review of Research in the Field of Nanorobotics. Intelligent Systems and Robotics Center Sandia National Laboratories. Albuquerque, New Mexico. October 2005. James F. Jones, Dannelle P. Sierra, and Nathan A. Weir.** *This source significantly contributed to the unit, since the topic of the source directly aligns with the central theme of this Unit. It details most if not all of the parts that make up the Nanotechnology industry. The information from this source supports the unit by providing the audience with a vast amount of background knowledge, which is also accompanied by diagrams and graphics to help with the explanations. I consider this to be a reliable because it had to endure a peer review before it could be released to the public.*

2) **Basics of Electrical Circuits. Dr. Sameir Abd Alkhalik Aziez, University of Technology, Dept of Electrical Mechanical Engineering. April 2014** *This source was utilized to provide background information on the basics of Circuitry. The unit, itself, is expansive and discusses many details about how electricity is manipulated throughout our world. The manipulation of electricity is a major part of the unit, especially since an entire lab is devoted to it. In that way, the information from the source supports the lab and gives students a robust understanding of the way electricity can be made to do what you want. However, because of the breadth of the source many parts of the source will be omitted from the unit to preserve time and scheduling expectations. I believe the resource to be reliable because it comes from a University of high standards and accomplishments.*

3) **Fruit-Power Battery | Experiments | Steve Spangler Science. https://www.stevespanglerscience.com/lab/experiments/fruit-power-battery, 2013.** *This source was utilized as a lab in this unit. Parts of this lab were used to create the lab Fruit Battery lab for this unit. The lab will supports the unit, in that it helps the students understand what electricity is and how it can be manipulated. I trust this source to be reliable because the experiment is legitimate and has been proven to work many times over.*

4) **Introduction to Robotics. Sookram Sobhan, Polytechnic University, http://mechatronics.poly.edu. June 2003** *This source served as the introduction to our seminar and unit. Much of the information on the history and development of robotics included in this unit was derived from this source. Therefore, it plays a critical role in the unit and helped to shape the foundation of what the students will build on throughout the unit's entirety. I trust this source to be reliable because it was created by a member of a prestigious university and then transferred to me via my seminar leader.*

5) **[Voltage, Current, Resistance, and Ohm's Law - Learn.SFE](https://learn.sparkfun.com/tutorials/voltage-current-resistance-and-ohms-law/an-ohms-law-experiment), https://learn.sparkfun.com/tutorials/voltage-current-resistance-and-ohms-law/an-ohms-law-experiment. February, 2013.**
This source basically serves the purpose of providing guidance and support for the way to execute the activities in the unit. This is because the sources is filled with animated diagrams that thoroughly explain the proper techniques to use when setting up the different parts of the activity. It also supports the unit by involving the students in hands on activities that promote learning through discovery rather than regurgitation. I trust this source to be reliable because this source provides information that is aligned with many of the concepts in the unit. In addition, the person who posted this source also has posted many other sources that all seem to be accurate and well prepared.

Appendix
PA Common Core Standards

- **3.4.10.B2:** Demonstrate how humans devise technologies to reduce the negative consequences of other technologies.
- **3.4.12.B1**: Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of technologies
- **3.4.10.B4:** Recognize that technological development has been evolutionary, the result of a series of refinements to a basic invention.
- **3.4.10.C2:** Analyze a prototype and/or create a working model to test a design concept by making actual observations and necessary adjustments.
- **3.4.12.E1:** Compare and contrast the emerging technologies of telemedicine , nanotechnology , prosthetics, and biochemistry as they relate to improving human health.

ROBOTICS MECHANISM: MECHANICAL ELEMENTS

1. Inclined plane wedge
2. Gear, rack, pinion, etc
3. Chain and sprocket
4. Cam and Follower
5. Slider-Crank
6. Linkage
7. Lever

WHAT CAN ROBOTS DO?:

- Jobs that are dangerous for humans
  - Decontaminating Robot: ie. Cleaning the main circulating pump housing in the nuclear power plant
- Repetitive jobs that are boring, stressful, or labor-intensive for humans
  - Wielding Robot (Cars or other machinery)
- Menial tasks that human don’t want to do

    - ScrubMate Robot (cleaning toilets)

Industries
Space- NASA Space Station
Hazardous Environments

- TROV in Antarctica operating under water
- HAZBOT operating in atmospheres containing combustible gases

Medical

- Robotic assistant for
  micro surgery

Home

- Sony SDR-3X Entertainment Robot
- Sony Aido

Future

- Artificial Intelligence
- Autonomy
    - Robot Work Crews
    - Garbage Collection Cart
- Humanoids
    - Honda Humanoid Robot
- Nanotechnology/ Nanobots

- Agriculture
- Automobile
- Construction
- Entertainment
- Health care: hospitals, patient-care, surgery , research, etc.
- Laboratories: science, engineering , etc.
- Law enforcement: surveillance, patrol, etc.
- Manufacturing
- Military: demining, surveillance, attack, etc.
- Mining, excavation, and exploration
- Transportation: air, ground, rail, space, etc.
- Utilities: gas, water, and electric
- Warehouses

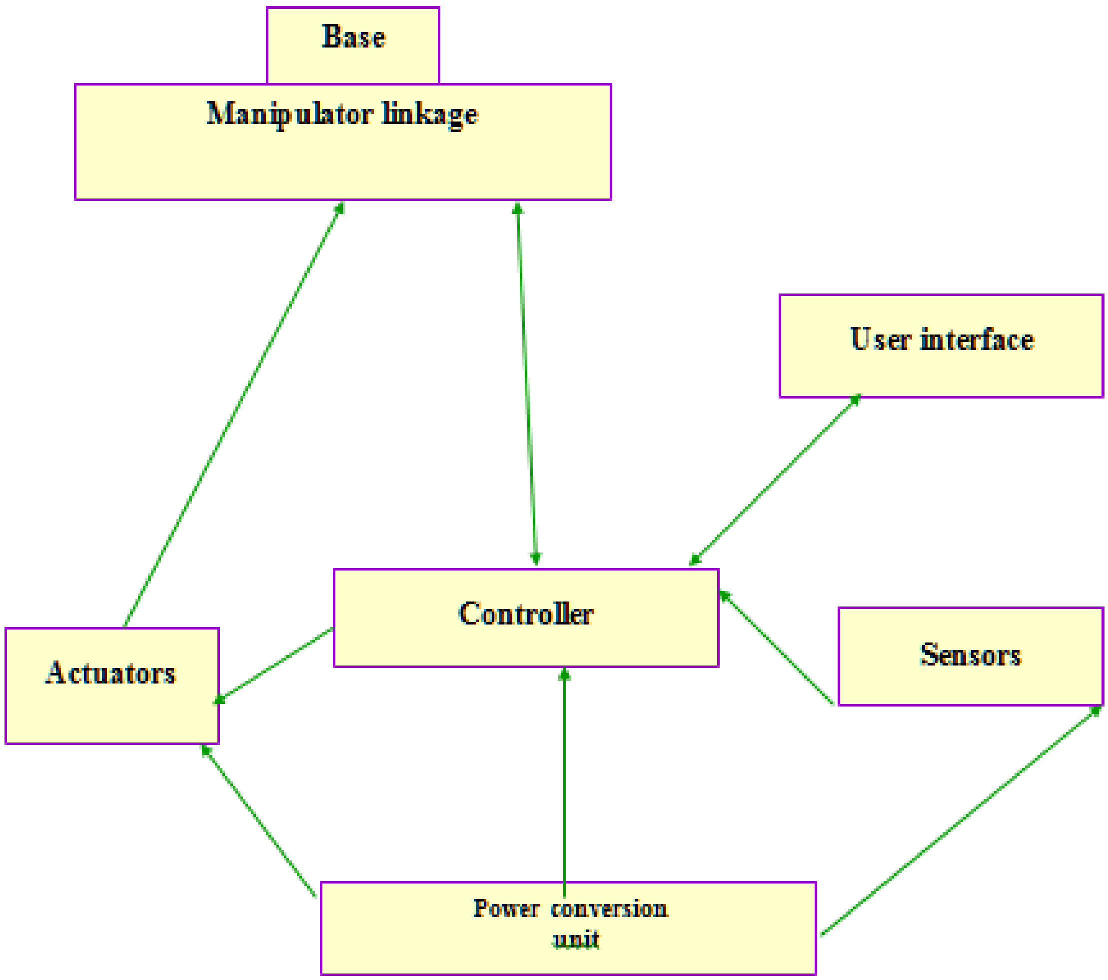
Systems of Unit (S.I.):-

Quantity	**Unit**	**Symbol**
1)Charge	(q) Coulombs	C
2)Current	(I) Amper	A = C / S
3)Force	(F) Newton	N
4)Work , energy	(w) Joule	J=N.m
5)Voltage	(V) Volt	V = J / c
6)Power	(P) watt	w = J /s = V. A

- 7)Length (l) meter m
- 8)Temperature (T) Kelvien K

Three nanomanipulation techniques are presented: (20)

1. The first technique uses electrostatic attraction to pick up a particle and deposit the particle at a different location on a substrate (i.e., what the authors refer to as “nanocrane”). A particle can be picked up by the repeated application of negative and positive tip voltages. It is assumed that this process charges the particle and therefore causes electrostatic attraction between the particle and probe tip. Then the particle can be moved to a different location and deposited by repeating the same process (i.e., applied positive and negative voltages).
2. The second method investigates the simultaneous manipulation of a line of nanoparticles by rapidly sweeping the AFM tip perpendicular to the direction of slower forward motion. Using this method, it was shown that a sparse “field” of particles could be manipulated into dense lines (i.e., referred to as “nanobroom”).
3. The last technique investigates the mechanical pushing of individual nanoparticles to form dense lines as well as a circle made of six nanoparticles down to a precision of about 10 nm



Key Components