



Activity Template

Subject Area(s)

Science & Technology

Associated Unit

Degrees of Freedom

Activity Title:

“Designing a Robotic Arm”

Grade Level:

7th-8th

Time Required:

2 class periods

Group Size:

3 students per group

Expendable Cost per Group

US \$15

Summary

In this activity students learn about the engineering design process from identifying a problem that affects people, brainstorming how to fix it, coming up with ideas and making a prototype. Students will then build their design for a robotic human arm that allows a person to pick up a cup of water and bring it to the mouth.

Engineering Connection

Engineers in industry use a well-defined model to design a new product. It usually involves identifying a problem, brainstorming solutions, designing a prototype, manufacturing, testing and evaluating the device. It is important for students to learn this process so they can get an idea of what engineers do from day to day.

Furthermore, designing a robotic human arm is an important model to study as there is a huge demand for developing prosthetic devices for soldiers who return from war.

Keywords

Bionic, Brainstorming, degrees of freedom, prosthetics

Educational Standards

- Science: 3.6.12.A
- Science: 3.6.10.A & C

Pre-Requisite Knowledge

- Introduction to robotic arms
- Motion of the human arm and the robotic arm.

Learning Objectives

After this lesson, students should be able to:

- Identify the steps in the engineering design process
- Recognize the complexity in mimicking the motion of the human arm
- Build a robotic human arm

Materials List

Each group needs:

- Popsicle sticks
- String
- Glue
- Styrofoam cups
- Scissors
- Wire
- DC Motor
- Switch
- PVC pipe
- Aluminum rod
- Rubber bands

Introduction / Motivation

Engineers are problem solvers. When they are given a problem to solve, they work together with other engineers to draw up ideas to creatively solve those problems usually in the form of a device. For example, currently there is a big need to design prosthetic limbs for soldiers who have lost their arms or legs during war. To do this,

engineers have spent most time drawing their ideas on paper, building prototypes and testing them to see what will and will not work. Today in class we are going to use the engineering design process to design and build a bionic arm. Before we get started I want all of you to watch the inspiration for this activity, which is an episode from the news television show 60 minutes that did a story on engineers who are currently designing prosthetic limbs. I want you to pay close attention to what the engineers in the episode talk about. For example, what is the problem they have to resolve? What are some possible solutions? What is their design process? After the movie is over, in your groups you are going to design a robotic arm that will help a person pick up a cup of water and bring it to their mouth so they can drink it.

Vocabulary / Definitions

Word	Definition
Bionic	Using electronic devices and mechanical parts to help humans accomplish a task
Brainstorming	A group problem solving strategy where all members of the group write down their ideas on a piece of paper
Degrees of Freedom	The different ways that an object can move or rotate. The human arm has 7 degrees of freedom.
Prosthesis	An artificial device used to replace a missing part of the body

Procedure

Background

The overall point of this activity is that students learn how engineers go from an idea to a product. Engineers have a design process that leads them through each step [2]:

1. Identifying the problem
2. Developing design specifications
3. Developing concept designs and evaluate them
4. Selecting of final design
5. Manufacturing a prototype
6. Testing and evaluating
7. Making modifications if necessary
8. Writing documentation
9. Manufacturing final device

Steps 3, 6, and 7 are repeated numerous times until they form a working solution. But in the end they form a working device that addresses the problem and can be delivered to the customer. It is important to take the students go through the first half of these steps.

In the activity the students will have to look at all of the materials given and brainstorm on how they can build an arm that will help a person without an arm pick up a cup of water and drink it. Usually in the engineering process you are not given the materials first so then the engineer has to balance their budget, another constraint that can limit their ideas. In its simplest form, the robotic arm only needs to have one degree of

freedom, movement in the up direction to lift the cup to the mouth. Two of the most common solutions to the grabbing mechanism will be to either design the cup so that it easily fits into the arm or build a hand that will grasp the cup.

Before the activity

- Gather all supplies and make sure to have enough for each group
- Cut PVC pipes into three 1 foot pieces
- Drill a hole through the end of the PVC pipes
- The activity will go much more smoother if the motor is already attached to the switch and the battery

With the students:

Students will be divided into groups of 3 and each given all of the materials. Between each step the teacher must sign off on their work. Time distribution:

1. Ten minutes to brainstorm ideas on how they will use their supplies
2. Five minutes to pick and draw the design they plan to build
3. Thirty minutes to build their device with the supplies given
4. Five minutes to test their device
5. Ten minutes to make any modifications to their device
6. Five minute final oral presentation on design

There are different ways that students can build their robotic arm but here is one way that they can do it using the supplies provided:

1. Start by attaching the string to the motor shaft and the other end of the string to one end of one of your PVC pipes.
2. Cut Styrofoam cup in half.
3. Attach each cup half to the end of two Popsicle sticks; this will represent the hands.
4. Connect Popsicle sticks to PVC pipe, which will represent the forearm
5. Position the three PVC pipes so the holes are aligned. The outside pipes now represent the upper arm.
6. Place aluminum rod through holes and make sure it is tightened. The middle PVC pipe should now be free to turn.
7. Clamp down the motor to the upper arm.
8. Place rubber bands around the drinking cup to give it some traction
9. Test the robotic arm to see if it can pick up the cup of water.

Investigating Questions

1. After you brainstorming session, how did your group choose the route to build your prototype?
2. Does your design drawing match your robotic arm? What changed about it?
3. Did you design idea change while you were building it? If so, what made you change it?
4. Did your device solve the problem?

Assessment

Pre-Activity Assessment

Title: Problem statement

As a class, agree on what the problem constraints will be. The problem is to design a prototype for a prosthetic arm that will pick up a cup of water. With the students further define the problem statement by asking the students what they think will be possible. For example, one degree of freedom, will the other free arm be able to help, can the cup be altered, etc? This will allow students to critically think of the problem at hand and dig deep into what the customer actually needs.

Activity Embedded Assessment

Title: Product drawing and presentation

Before the students are given access to the materials have them draw their design. This will help them visualize their ideas and make sure the whole team is on the same page. After the teams finish building their prototype they will have to present their product to the whole class. They must show how it works, explain how they came up with this idea, and discuss some areas for improvement.

Post-Activity Assessment

Title: Class wrap up

After all the presentations conclude, a class discussion will follow on a topic determining which design met all the goals that were defined in the problem statement. Students should try to analyze what worked for that team and describe improvements their team could make.

References

1. 60 minutes video: Creating The Bionic Arm
http://www.cbsnews.com/video/watch/?id=4937716n%3fsource=search_video
2. D.A. Rice, R.J. Hirko, A.H. Hoffman, H.K. Ault, and R.C. Anderson. "Assistive technology transfer and the NSF bioengineering research to aid the disabled (BRAD) program." *Technology and Disability*, 7 (1997) 47-54.

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