Yale-New Haven Teachers Institute

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Robotics in the Medical Field

Curriculum Unit 14.04.05
by Jonathan Cap

Introduction

In Robotics class, students cover the six simple machines: lever, pulley, incline plane, wedge, screw, and wheel and axle. This knowledge will be used to teach the following unit. Robotics in the medical field will cover the following topics: minimally invasive robotic surgery, prosthetics, nanobots, and the mechanics of flagellum and bacterial motility. By understanding how simple machines are mimicked in nature and how robotics is advancing the medical field, students will have a deeper understanding of how robotics are becoming a part of our everyday lives. This will allow students to think outside the box when creating projects for this unit, future units, and their everyday lives.

Classroom lessons and activities include: how nature is mimicked in robotics, the history of prosthetics, and Da Vinci artist or machine.

How nature mimics robotic movement: In this lesson, students will learn about the topic of mechanics of flagellum and bacterial motility. Students will see how even things on the microscopic level use simple machines to create movement. Although there are no gears and motors as we think of from our own society, students will see how cells are made up to create movement. They will see the similarities from traditional motors to how these cells operated. This will then tie into the way nanobots are being created for use in the medial field.

History of prosthetics: Students will learn the history of prosthetics and see how technology has changed their use and the efficiency for people who need them. Students will look at current prosthetics and brainstorm how they could improve them. This can include material and/or design. Students will use hand drafts and digital designs to demonstrate their ideas to the class. Students will explain why they feel their design will improve the field of prosthetics. The student will back up their designs with research and facts that they have gathered for this lesson.

Da Vinci artist or machine: Students will learn about robotic surgery and how it has advanced the medial field and quality of life for people. Students will look at the machines used for robotic surgery, and then will identify the simple machines it is made up of and how these machines are put together to then create the robot that is used.

Teaching strategies will include acting out systems (using their bodies/movements to act out a system), cooperative learning, interdisciplinary teaching (pairing with math), daily reviews of previously learned material, teaching vocabulary throughout the unit, graphic organizers, hands on/ active participation, video/ visual graphs, problem solving instruction, and gamification (replacing traditional unit evaluation, such as tests and quizzes, with a game/competition to evaluate their created robot).

The unit will align to each of New Haven Public Schools 21 st Century Competencies: Problem solving and critical thinking; creativity and innovation; communication and collaboration; initiative, self-direction, and accountability; citizenship and responsibility; and access and analyze information.

Problem solving and critical thinking, creativity and innovation, and communication and collaboration will be use throughout the unit. It will be seen in all the activities in order for the students to create their own design and make modifications throughout the process.

Initiative, self-direction, and accountability, and citizenship and responsibility will be seen more in the group work sessions. Students will have to meet deadlines, give their peers feedback, and reflect on their own experiences.

Standard for Technological Literacy

Standards:

The Nature of Technology

1. Students will develop an understanding of the characteristics and scope of technology.
2. Students will develop an understanding of the core concepts of technology.
3. Students will develop an understanding of the relationship among technologies and the connections between technology and other fields of study.

Technology and Society

4. Students will develop an understanding of the cultural, social, economic, and political effects of technology
7. Student will develop an understanding of the role of the influence of technology on history.

Design

8. Students will develop an understanding of the attributes of design.
9. Students will develop an understanding of engineering design.
10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

11. Students will develop the abilities to apply the design process.
13. Students will develop the abilities to assess the impact of products and systems.

The Designed World

14. Students will develop an understanding of and be able to select and use medical technologies. [1]
15. Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
17. Students will develop an understanding of and be able to select and use information and communication technologies.

Background Knowledge

Metropolitan Business Academy is a magnet school with a business focus. Our school currently has 378 students enrolled with a capacity of 400 students. The goal is to have 100 students in each grade. There are approximately 86 students in the senior class, 80 students in the junior class, 110 in the sophomore class, and 104 students in the freshmen class. Because we are a magnet school, half of our students are supposed to come from urban districts, in this case, New Haven, and half are supposed to come from surrounding suburban districts, like Branford, North Haven, and Wallingford. Currently, sixty percent of our students are from New Haven and forty percent are from suburban districts within a thirty-mile radius. Our school is made up of forty percent Hispanic/Latino students, forty percent African American students, and twenty percent Caucasian or other, mostly Asian, students. Every year, our school becomes a little more diverse.

There are four pathways in our school that students can choose after their ninth grade year. The pathways include: allied health & science, law & political science, digital media and technology, and finance. Every student must enroll in one pathway, but students can take courses outside of their pathway as an elective if there is room in the class. In robotics, there are mostly students who are in the technology pathway, but I also have students who are taking it as an elective. This particular robotics course is for juniors and seniors who have already taken Algebra 1 and Geometry, and students who have or are currently enrolled in Algebra 2. In science, these students have taken physical chemistry, biology, and have taken or are enrolled in chemistry.

Unit overview

The purpose of this unit is to show the relationship between robotics and the medical field. With the advancement of medicine and the advancement of technology these fields are weaving and growing together. With needs in the medical field, it supports the development of new technologies, and with the development of new technology, it allows the advancement of medicine showing how science, medicine, and technology (Robotics) all overlap and support each other. This will also show possible careers in these fields.

This unit will be a total of eight, 87-minute periods. There will be three topics that will be covered with accompanying activities and projects, like how nature mimics robotic movement, history of prosthetics, and Da Vinci artist or machine. Each topic will be two 87-minute periods. One period will introduce the unit and talk about the topics that will be covered. The last period will be used to close the unit and have final group discussion with guiding questions to foster group discussion. When the unit is complete, students will understand how robotics and robotic principals are integrated in nature and the medical field.

Design process and grading system

This course is designed to have students grow across the New Have Public Schools 21 st Century Competences. This consist of the following:

1. Problem Solving and Critical Thinking
2. Accessing and Analyzing Information
3. Communication and Collaboration
4. Creativity and Innovation
5. Initiative, Self-direction, and Accountability
6. Citizenship and Responsibility

For more information and in-depth descriptions to design a rubric please visit:

www.nhps.org

Students are required to complete a design report for each assignment where a robot is designed and built. This revolves around the engineer design process that was modified for classroom use. This is a continual cycle showing how even when something is complete it can always improve as new materials, technologies,

and ideas that are developed. (See Figure 1.)

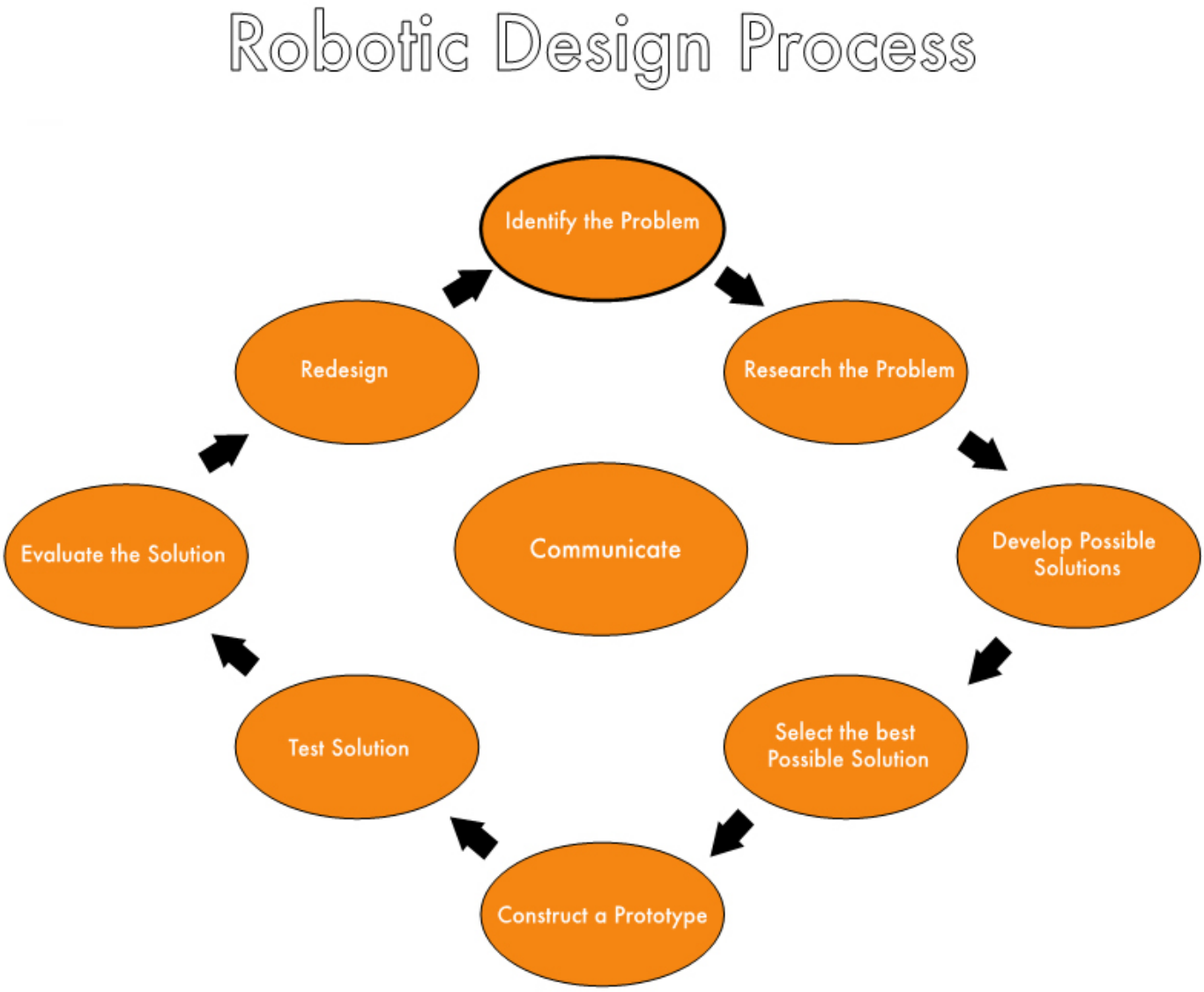

Figure 1.

Below is an example of the design report that is used in class. This is given to students as a Microsoft Word Document. Students will use this layout for each assignment and can open and type in the document then submit it when complete.

Robotics Design Report

Identify the Problem

What is the problem? What are the restraints?

Research the Problem

Are there previous solutions for this problem? Are there similar problems that were solved? If so, how was it solved?

Develop Possible Solutions

Explain the solutions and how they will work. Include pictures of sketches and graphic organizers.

Select the Best Possible Solution

What is your solution? Why is this the best?

Construct a Prototype

Include picture of completed prototype.

Test Solution

Take notes and/or video for your records

Evaluate the Solution

What worked well and why? What did not work well? What can be changed to make this better?

Redesign

If your design didn't work and/or you can improve it, review your findings from your design report and redesign.

This document is meant to guide the student to success for each assignment and allow a structure to write the report. At the end of each assignment, students have a well throughout and organized report that can be used in their portfolio to showcase their work and progress throughout the year. Please use your favorite method or rubric to grade these reports. During this brainstorming process students are encouraged to use graphic organizers to collect and organizer their ideas, along with their group's ideas. The one that is the most versatile is a web chart, which centers around a subject or problem, solutions and ideas can branch off. This graphic organizer can be ever expanding. See Figure 2.

Example of Web Organizer

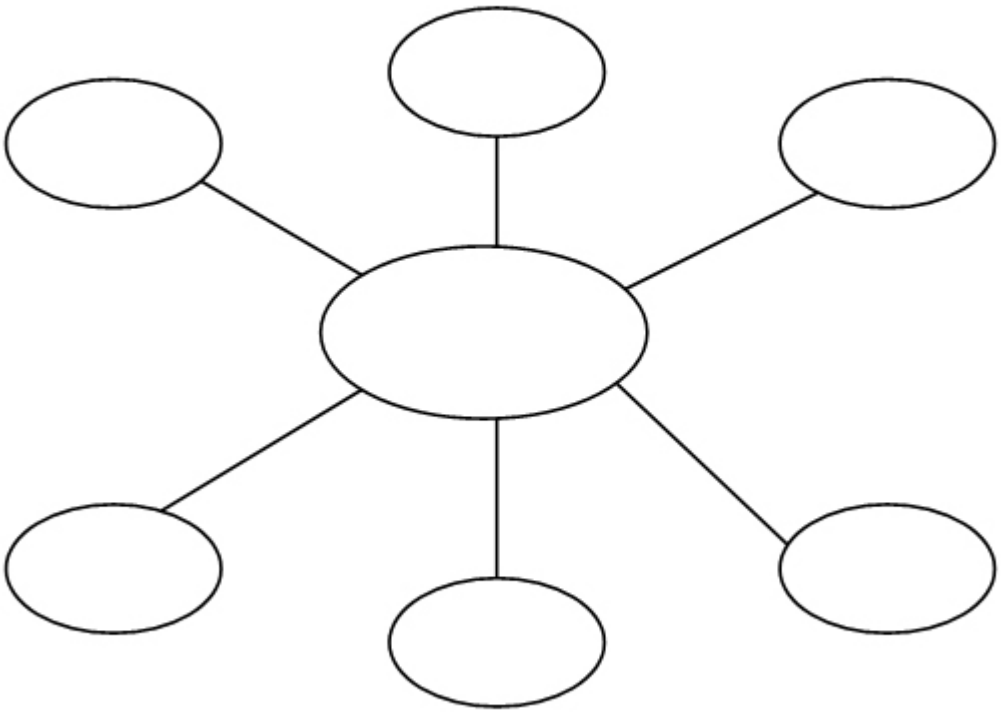

Figure 2.

This class is also based on the teaching practice of gamification. This takes lessons, projects, and assignments and gives them a point value as opposed to a traditional letter grade. This then turns any assignment into a game rather than schoolwork. It allows for students to develop a connection the assignment as they would their favorite game. It also takes students who may not like and/or do well with traditional grading and give it a different platform to showcase their learning and skills as they are developed. Students also gain skills with teamwork and sportsmanship. The teacher can set up their course in a few ways when using this system. First, each student needs to receive a certain number or points to pass for the marking period. Different value of points can represent different letter grades; for example, an A letter grade could equal 500 points, B could represent 400 point, etc. Different assignments and projects can be a certain amount of points, and student can choose what they will complete in order to accumulate their points. Points could be awarded to students who help their peers achieve goals and success, as well as for putting extra time into their work. Another way is to have each project broken down into points, and students receive points for each step completed. This is how the project written out in this unit will be formatted. This is a nice way to set up students to think outside the box and succeed. Students will realize that they don't always need to complete all the tasks in the project briefing to do well. If there is a part that they can not figure out how to complete, they can find a way to gain points in a different way, and they will be able to calculate how they and their group will do before the assignment is submitted and tested. This makes a very clear and visible grading practice for students, parents, and teachers. Allowing the students to test their work until the due date and make modifications as needed to improve their work gives them the confidence and skills to solve real world and working condition problems. They use the design report through out these projects.

Part of the 21 st century competences are Communication and Collaboration, as well as Citizenship and Responsibility. Students will learn how to work better in groups and also take responsibility for their work and actions. In this course, students receive three grades for each project. One is for their design report, another is for their group project, which is calculated with points, and the third is a participation grade. This participation grade was developed while working and brainstorming with other colleagues. In Robotics, students work in groups for a majority of the projects. If a group of four earns an 80% on a project, the final product, the group will receive 80 points for each member, totaling 320. The group will be given the 320 points and asked to divide the points amongst themselves. Each group member will write how many points out of the 320 that they deserve and why they deserve those points. The group will share their answers and come to a consensus to determine how many points each of them has earned based on their effort and participation in the group. The group must then write out a justification explaining why they each deserve the amount of points. Their decisions will be entered as a participation grade.

For example, if Student A, B, C, and D earn an 80 they will receive 320 points in total. Student A and B did most of the work and were only absent once. They could give themselves 90 points each; now there are only 140 points left. They may think that student C did a good job but was absent three times, so that student deserves 80 points. As for student D, that student skipped class a few times, and while in class, didn't contribute and would socialize with other groups. Student D would get the remaining 60 points. All the group members would come to consensus and write up their justifications for a participation grade during the classes closing activity and reflection time.

Lessons/Classroom Activities

History of Prosthetics

Briefing: Prosthetics have been around for hundreds of years. There are documented cases of the use of wooden and metal arms and legs that go back to the Egyptians. Prosthetics have advance tremendously in the last few years. They now have different designs and are made of different material based on the patient's personal needs and functions that need to be accommodated, whether it is to walk, run, pick up specific items, etc.

You will research this topic individually and answer the following questions:

What are some significant achievements in this field? What is the timeline of growth in this field? What materials have been used?

Once the research is done individually, students will meet in their groups and share their findings. Group members will then brainstorm ways to design a prosthetic leg for a dog. Students will think about ways in which a dog moves and lives. To make this a fair design problem for all, we will all design the leg for a Labrador Retriever. This will allow students to research the trait that this K-9 has to better suit their design. Think about shape, material, how it will be made and work, and last but not least, the estimated cost of the unit. Students will follow the design process and make a prototype out of any material they wish. Students will be provided with, but are not limit to, vex kits, cardboard, paper, tape, and glue. Once the prototype is complete, students will prepare a presentation to share with the class. Students may use Microsoft PowerPoint

or any other form of presentation as long as it includes the following: A visual to show the workings of their design, the groups design process, and explain how they came up with their design.

Da Vinci artist or Machine

Objective: Students will learn about robotic surgery and how it has advanced the medical field. Students will then design a robot that will be able to remove an object that is submerged in jello. The students will remove this object leaving the jello as untouched as possible.

Rational: The jello will represent human tissue, and there will be different layers to represent the different layers of tissue on our body with different tensile strengths. The purpose of this will show students how robotic surgery needs to be precise and detailed; showing how incisions must be made and go through different thicknesses of tissue.

Mission: Da Vinci artist or Machine

Briefing: The DaVinci Surgical System is a state of the art machine helping surgery to happen with only a few incisions. The hand movement of the doctor is translated into smaller more precise movements from the surgical instruments that are attached. The surgeon must understand the tissue tensile strength for each operation. The idea behind robotic surgery is to be minimally invasive, which allows for faster healing time for the patient. Many common sports injuries, such as torn ACL and meniscus, are now done in this way, which speeds up healing time.

Your mission, should you choose to accept, will be to create a robot that will be able to insert an object into the proper tissue layer without causing further damage to the area.

Constraints: Students will be given a two-inch by quarter inch nail. Each group will be given a plastic container that will have a balloon filled with dye, and this balloon will be submerged into gelatin (jello). Students will have three chances to insert the nail into the tissue (jello) causing as little damage to the jello while going as deep as they can without puncturing the balloon. (See Figures 3 – 5)

Figure 3.

Figure 4.

Figure 5.

Materials:

Jello or gelatin

Balloon

Food coloring or any contrasting liquid to fill balloon with

Nails

Transparent container

Point System:

Design Report = 100 points

Completed Robot Construction = 50 points

Move from starting point to base of container = 10 points

Engage nail with jello = 10 points

Insert nail past checkpoint 1 = 10 points

Insert nail past checkpoint 2 = 10 points

Insert nail past checkpoint 3 = 10 points

Pop Balloon = -15

Groups will have a tolerance of one half of an inch for the insertion point on the surface area of the jello. 1 point will be deducted for each 1/8 of an inch of more "damage" that is made to the surface of the jello.

Every second the group goes over the two-minute time limit: -1 for each second over

Bonus:

Surgery requires detailed instructions and explanations from all involved. The surgeons and the people in the operating room assisting need to keep open, detailed, and positive communication throughout the procedure. After each group completes this task, we will do it blind. This cannot count against your group. The student who is controlling the remote will be blind folded. One of the other group members will give verbal instructions and commands to insert the nail into the surface of the jello. If the group can successfully insert the nail into the jello with out popping the balloon, the group will receive 10 bonus points.

Instructor tips:

Any container can be used for this project. The container must be large enough to hold the balloon in it. For this project, a four and a half cup measuring container was used. This allowed a five-inch balloon to be inflated to approximately four inches and filled with a liquid. It is extremely hard to fill the balloon with liquid, without a small amount of air getting in, which will case it to rise a little out of the jello, as seen in Figure 3. It is nice to use a container that has a measurement mark, so all groups will be able to practice inserting the nail into the jello and the containers can consistently be filled at the same measurement. For this project, the container was filled at the four-cup mark. Any size or shape nail, or other object, can be used to insert into the jello with out popping the balloon. Depending on the container and balloon size, it can be the instructors discretion where the target area will be for groups to insert the nail. For this example, the nail was inserted around the perimeter of the balloon. (See figure 4) Part of the fun and learning experience will be the trial and error with each group's design and robot. When students practice, they will try their best to insert the nail as close and deep as possible to the instructor's target area. The closer they try to place the nail to the target area, the risk of the group puncturing the balloon will go up. If the balloon is filled with a different contrasting liquid than the jello, it will be very visible if the balloon is punctured. Most of the time if the balloon is punctured, it will pop and the group will know they went too far. (See Figure 5)

Robotic Careers

There are many jobs involving robotics. It could be the actual job of the robot, the repair of it, or designing new ways to make our lives easier. For this assignment, students will find and research a career in the field of robotics. There are endless careers, and new careers are being developed every day.

Name of career and Job Title:

Students will research a job and give at least a one-page description of the job. Include what background and experience one must have to qualify for this career. This can include educational background, such as college degree, vocational degree, or military affiliation. With training or education, include at least three schools/training facilities that one could obtain the degree from.

Students will cite their work with sites such as easybib.com or any other way they prefer to cite their work. Include all links that were used for this assignment. Plagiarism will not be tolerated. Once students are done

with this assignment, the class will gather as a group as share their findings. This will give all the students insight on different careers opportunities.

Works Cited

"Oxford Dictionary," Oxford University Press, last modified 2013, http://oxforddictionaries.com/definition/english/efficient?q=efficient. This is the best definition that pertains to our subject.

Standards for Technological Literacy : Content for the Study of Technology. Edited by International Technology Education Association, 210. Reston, Virginia: 2007. This is the International Standards for Technology and Engineering Education.

"Vex Inventor's Guide," Vex Robotics Design System, last modify May 2008, www.vex.com. This is the manual that comes with the products we are using throughout this course.