Research Experience for Teachers at WPI:

Bioengineering Design in the Middle School Classroom

Curriculum design process
&
Curriculum unit descriptions
2008

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Research Experience for Teachers Program: Inquiry-Based Bioengineering Research and Design Experiences for Middle-School Teachers

Getting Students Excited about Bioengineering

Middle-school is a critical time in the education of our nation's students. In particular, there is a need to provide them with more exposure to science and engineering, and to show them how these disciplines can be used to help society. In the WPI RET program, we provide hands-on learning opportunities for middle-school teachers in bioengineering. They return to the classroom full of ideas and knowledge on how they can pass this excitement on to their students – and the confidence to teach the engineering design process, since they have done it themselves.

Bioengineering is an area that lends itself well to the design of inquiry-based learning modules. For example, teachers can learn about assistive medical devices from WPI faculty, and they may then choose to design a curriculum unit for their students on the same topic.
The teachers in this program spent 6 weeks engaged in high level bioengineering work, alongside with WPI faculty and graduate students. They also developed units for their classrooms through a collaborative process. The teachers received feedback from each other and from external mentors before presenting these units in their schools.

If you are looking for ideas about how to engage middle-school students in inquiry-based bioengineering design activities, then the lesson plans presented here will give you complete information for several interesting examples.

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Research Experience for Teachers Program: Inquiry-Based Bioengineering Research and Design Experiences for Middle-School Teachers

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Celestial Support:

Designing Assistive Devices to Support the Compromised Skeletal Systems of Astronauts Returning from Long-term Space Missions

Robin Belisle

WPI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA

Introduction

Students are use to being exposed to different school subjects in isolation. As a result they often have difficulty seeing the connection between these discrete topics. In this unit I strived to create a mechanism that would help students see that natural connections exist between subject areas by:

- •Exploring how environmental or Earth Science based problems can be solved using the engineering design process
- •Incorporating bioengineering concepts to authentic Astronomy problems
- •Investigating to how bioengineering technologies are used to design and produce mechanical devices that improve health
- •Reinforcing the need for mathematical competency

Teaching Objectives and Constraints

Problem statement:

Design a curriculum unit to teach an aspect of bioengineering that will utilize the engineering design process to reinforce the concepts of weight, mass, volume and density and align with the standards set forth in the Massachusetts Science and Technology/Engineering Curriculum Frameworks.

Objectives:

- •Improve student understanding of weight, mass, volume, and density
- •Incorporate the use of the engineering design process in the classroom
- •Provide students with inquiry-based experiences
- • Increase student communication skills

Constraints

- •Time allocated to teach the unit
- • Meet the needs of a diverse learning populations
- •Standards set by the DOE Frameworks and department curriculum

Topics covered include: Physical Science (e.g., mass, volume, weight, & density), Earth Science, Mathematics, Science Inquiry, and Technology & Engineering (i.e., design process & assistive devices)

Student grade: 8th

Number of students: 20 to 24 per class working in groups of 2 to 3

Lesson duration: Six 45 minute class periods

Research/Background

During the development of this unit, the following solutions to the design problem arose:

- Design an assistive device for astronauts with weakened bones
- Design an emergency device that can be used for personal protection in the event of a sudden severe meteorological event
- Design a composite material to use in home construction that will support and steady a house in the event of an earthquake
- Design a composite patch that can be used to repair a hole in the forward window of spaceship in flight
- Design a composite patch that could be used to "patch-up" pot holes

Research:

- •Mass DOE Frameworks[1]
- •NSF Standards[2]
- •Teacher Discussion Groups

Chosen Solution

Student Problem: While in space, astronauts lose bone density which weakens their skeletal system. To protect astronauts from injury, after returning to Earth, design an assistive device that can help support their weight until their bones regain strength.

[1]

In space astronauts loose 1 to1.5% of their bone mass per month

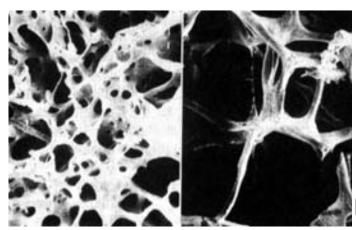
Client Statement: Using only materials provided, design and construct an assistive device that will support 20% of the weight of an individual while minimizing any impediment the device might have on mobility.

Objectives:

- •Strong enough to support 20% of the weight of the body
- •Light weight so that it doesn't further stress the body/skeletal system (cannot weigh more than 10% of the total body weight)
- •Should be reasonably stiff and comfortable for the user
- •Minimize any impediment the device might have on mobility
- •Should be easy to use
- •Should be made as inexpensively as possible

Constraints:

- •Must be designed and completed by groups of 2 or 3 students
- •Must be completed and ready to be presented within 6 days
- •Devices must be built to fit a diminutive 33" astronaut
- •Only materials "purchased" from the teacher can be used
- •Each group will have a maximum of "$1500.00" to purchase materials



[2]

Normal Bone Density **Bone Showing a Loss of Density (Often referred to as Osteoporosis)**

In this unit, students will be given an interesting, authentic problem to:

- •Investigate reasons for loss of bone density[3,4,5,6,&7]
- •Determine mass, weight, volume & density of pre-mission and post-mission bone samples
- •Work through the design process
- •Utilize the engineering design process to design and construct prototypes of assistive devices to support the skeletal systems of returning astronauts[7&8]

Assessment

Assessing the design:

- Graded on how well projects meet design constraints
- Will be tested to determine:
  - Amount of weight device can support
  - Range of motion

Assessing student learning:

- Lab based activities used to check for student understanding
- Production of artifacts will demonstrate understanding and competence
- Write-ups and/or class presentations will increase communication skills

Conclusions and Future

Conclusions

Students who successfully complete each section should be able to:

- •Differentiate between weight and mass
- •Define gravitational pull
- •Calculate the gravitational pull on an object at different locations
- •Differentiate between volume and mass
- •Define and calculate density
- •Describe and explain adaptive and assistive devices
- •Design and construct a prototype of an adaptive or assistive device

Future

Unit will be taught during October at Tantasqua Regional Jr. High School, results will follow

Acknowledgements

Special thanks to:

- • Project Mentors: Professors George Pins & Glenn Gaudette
- • RET program PIs: Professors Kristen Billiar & Terri Camesano
- • The graduate and undergraduate students who were invaluable in the lab: Jenna Balestrini, Katie Bush, Shawn Carey, Alex Christakis, & Jen Makridakis
- • Project partner: Mary Fusco
- • Independent assessor: Jeanne Hubelbank

References

References:

1 http://www.doe.mass.edu/frameworks/current.html

2 http://www.nap.edu/html/nses/overview.html#teaching

3 www.**space**du.com/SF%**2**0**Living**%**2**0and%**2**0**working**%**2**0in%**2**0**space2**.ppt

4 http://resources.yesican-science.ca/iss07/w3_lossInSpace.pdf

5 http://ocw.mit.edu/NR/rdonlyres/Aeronautics-and-Astronautics/16-423JSpring-2006/F80E68B5-CE20-44AB-A3EE-37BA7BFF0B86/0/bone_background.pdf

6 http://www.radiologytoday.net/archive/rt_080204p10.shtml

7 http://www.masterthescience.org/grades3-5/living/living.pdf

8 http://www.tryengineering.org/lessons/adaptivedevices.pdf

9 Dym, Clive L., and Patrick Little. Engineering Design: a Project-Based Introduction. 2nd ed. Hoboken, NJ: John Wiley & Sons, 2004.

Photo credits:

[1] http://www.mackins.co.uk/3-Drendering-21.php

[2] http://www.osteofoundation.org/Facts.html

Curriculum Unit and Assessment Plan

Celestial Support: Designing Assistive Devices to Support the Compromised Skeletal Systems of Astronauts Returning from Long-term Space Missions

RET Project Connection

Biomedical engineering research performed in Professor Pins' and Professor Gaudette's labs at WPI this summer formed the basis for this unit. In their labs they explore, among other things, how biocomposites can be engineered to fulfill specific needs, such as improving the function and health of human tissues (e.g., replacement skin and cardiac patches). This curriculum unit is a natural extension of work done in the lab. Our research showed how fibrin microthreads could be used as a scaffold to strengthen and support collagen gels when constructing biocomposite heart patches. Bone tissue, the subject of this curriculum unit, is a natural biocomposite that acts as a scaffold to strengthen and support the body.

RET Teacher Robin Belisle

School Tantasqua Regional Junior High School

Town/District Tantasqua Regional School District (Brimfield, Brookfield, Holland, Sturbridge, & Wales)

Subject(s) taught Earth Science

Subjects covered Physical Science (e.g., mass, volume, weight, & density), Earth Science, Science Inquiry, and Technology & Engineering

Grades appropriate 8^{th}

Lesson duration 6 - 45 minute periods

Goals/Objectives of lesson

Students will be able to:

Differentiate between weight and mass

Define gravitational pull

Calculate the gravitational pull on an object at different locations (e.g., different planets or out in space)

Differentiate between volume and mass

Define and calculate density

Utilize proper measurement tools and/or formulas to determine the weight, mass, volume, and density for selected objects

Describe and explain adaptive and assistive devices

Construct a prototype of an adaptive or assistive device

Background Information

The bodies of astronauts, while out in space, undergo many physiological changes due to the decrease in gravitational pull their bodies experience. Among these changes are loss of bone mass, space anemia, loss of muscle mass, in additional to changes in calcium and hormone levels. As a result of these biologic changes, bone density decreases in astronauts at a rate of 1 to 1.5% per month while out in space. This loss of bone mass results in weakened, brittle bones, a condition often referred to as osteoporosis. Fortunately for the health and well being of these astronauts, the loss of bone mass experienced in space can be reduced by participating in weight bearing activities while in space and can be reversed after returning to our planet and the gravitational force it exerts.

Essential questions

How do weight, mass, and volume differ?

What is gravity and what affect does gravitational force have on weight?

What is density and how is it determined?

What happens to bone density in space?

How can adaptive and assistive devices help improve the health and/or function of the human body?

Links to Frameworks and Standards - National/NSF

Content Standard A:

Abilities necessary to do scientific inquiry

Understanding about science inquiry

Content Standard B:

Properties and changes of properties of matter

Content Standard C:

Structure and function in living systems

Content Standard D:

Earth in the solar system
Content Standard E:
Abilities of technological design
Understanding about science & technology

Links to Frameworks and Standards - State

Earth and Space Science, Grades 6-8
The Earth in the Solar System
8. - Recognize that gravity is a force that pulls all things on and near the Earth toward the center of the Earth.
10. - Compare and contrast properties and conditions of objects in the solar system to those on Earth.
Life Science (Biology), Grades 6-8
Systems in Living Things
18. - Identify the general functions of the major systems of the human body.
Physical Sciences (Chemistry & Physics), Grade 6-8
Properties of Matter
31. - Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
32. - Differentiate between volume and mass. Define density.
33. - Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools and knowledge and appropriate use of significant digits.
Technology/Engineering, Grades 6-8
1. Materials, Tools, and Machines
1.1 – Given a design task, identify appropriate materials based on specific properties and characteristics.
2. Engineering Design
2.1 – Identify and explain the steps of the engineering design process.
2.2. – Demonstrate methods of representing solutions to a design problem.
2.3. – Describe and explain the purpose of a given prototype.
2.4. – Identify appropriate materials and tools needed to construct a given engineering design.
2.5. – Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.
7. – Bioengineering Technologies

7.1. – Explain examples of adaptive or assistive devices.

Links to Frameworks and Standards - Local

Tantasqua Junior High School's curriculum is based upon the Massachusetts State Frameworks and standards

Materials Required

Materials for measuring/determining mass, weight, volume, and density:
Metric rulers
Triple-beam balances
Graduated cylinders
Spring scales
"Bone" specimens cut from
1" polystyrene foam- 1 lb density
1" polystyrene foam- 2 lb density

Materials used for reference (optional)

Model of human skeleton
Posters of human skeletal system

Materials offered to the students for constructing their adaptive or assistive devices (materials actually used will depend on individual designs):

¼" x 48" wooden dowels
Plastic drinking straws (both bendable & rigid)
Flexible vinyl tubing(¼" internal diameter)
Masking tape
Rubber bands
String or twine

Lesson Development

Day 1

Introduce lesson by showing power point presentation “SF Living & Working in Space 2”

www.spacedu.com/SF%20Living%20and%20working%20in%20space2.ppt

Complete “Combating Bone Loss In Space” a modified version of the “LOSS IN SPACE” activity adapted from

http://resources.yesican-science.ca/iss07/w3_lossInSpace.pdf

Day 2

Complete “Investigating Changes In Bone Density” laboratory activity

Day 3

Utilize power point presentation “Celestial Support: Using the Engineering Design Process to Support the Wellbeing of Astronauts” to introduce the project and the engineering design process

Identify the design problem

You have been in space searching for evidence on Ceres, as well as several other large asteroids in the asteroid belt, that would help support the nebular theory’s explanation of how our solar system was formed. While in space your body, due to the absence of the Earth’s gravity, underwent several physiological changes. One of those changes, caused by the lack of weight bearing forces on your skeletal system, has resulted in the weakening of your bones and puts you at risk of breaking your legs when you step from your craft back on the Earth’s surface. To protect yourself from injury you will need to design an assistive device that can be used until the bones in your legs are once again able to support your weight.

Client Statement:

Using only materials provided, design and construct an assistive device that will support 20% of the weight of an individual while minimizing any impediment the device might have on mobility.

Objectives:

Strong enough to support 20% of the weight of the body

Light weight so that it doesn't further stress the body/skeletal system (cannot weigh more than 10% of total body weight)

Should be reasonably stiff and comfortable for the user

Minimize any impediment the device might have on mobility

Should be easy to use

Should be made as inexpensively as possible

Constraints:

Must be designed and completed by groups of 2 or 3 students

Must be completed and ready to be presented within 6 days

Devices must be built to fit a diminutive 33" astronaut

Only materials "purchased" from the teacher can be used

Each group will have a maximum of "$1500.00" to purchase materials

Begin student research- complete activity sheets and develop 2 possible solutions

Day 4

Students create drawings of possible assistive device prototypes

Students select best possible solution

Students begin constructing prototype of assistive device

Day 5

Continue construction of prototypes

Students test and evaluate their designs

Prepare class presentations of assistive device

Day 6

Classroom presentations of design projects

Assessment

A project based assessment will be used to assess the students' learning. Lab based activities will also be used during lesson development to check for student understanding at various set points within the unit. Having students, working in groups, work through the design process and produce an artifact will be one way that students can demonstrate their understanding and/or competence, while at the same time improve their communication skills. Write-ups and/or class presentations will allow students to share what they've learned while also increasing their communication skills.

References

http://www.nap.edu/html/nses/overview.html#teaching National Science Education Standards
http://www.doe.mass.edu/frameworks/current.html Massachusetts Curricula Frameworks
www.**space**du.com/SF%**2**0**Living**%**2**0and%**2**0**working**%**2**0in%**2**0**space2**.ppt power point depicting physical changes to the body resulting from space travel
http://www.tryengineering.org/lessons/adaptivedevices.pdf provides lesson plans for teaching about assistive devices
http://www.me.wpi.edu/Research/ATRC/ resource about assistive devices
http://resources.yesican-science.ca/iss07/w3_lossInSpace.pdf activity used to explore the amount bone loss that occurs in space
http://ocw.mit.edu/NR/rdonlyres/Aeronautics-and-Astronautics/16-423JSpring-2006/F80E68B5-CE20-44AB-A3EE-37BA7BFF0B86/0/bone_background.pdf background explaining changes that occur to the body in space
http://www.masterthescience.org/grades3-5/living/living.pdf lesson plans regarding changes to the body while living in space
http://www.radiologytoday.net/archive/rt_080204p10.shtml background regarding changes in bone density due to the reduced gravitational conditions of space
Dym, Clive L., and Patrick Little. Engineering Design: a Project-Based Introduction. 2nd ed. Hoboken, NJ: John Wiley & Sons, 2004.

Main title: How can Density of Materials be used to Design a Protective Helmet

Tanea Cezar
WPI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA

Introduction

Develop a curriculum unit related to Bioengineering using the Engineering Design Process, which will attend the State of Massachusetts standards which includes Properties of Matter, more specifically mass, weight, volume and density.

* Figure 1 Clip Art

Teaching Objectives and Constraints

The aim of this project is to develop a curriculum module based on the Massachusetts Department of Education frameworks, which requires the students to learn the Properties of Matter specifically mass, volume and density. This module will incorporate Bioengineering and the use of the Engineering Design Process.

Objectives:

•Learn the concept of SI measurement
•Apply the concept of measurement to find mass and volume of different materials.
•Apply the concepts to find density of the materials
•Use Bioengineering concepts and the Engineering Design Process

Constraints

Long curriculum to teach and not much time
Lack of classroom materials and technological tools
Students with different languages and backgrounds

Topics covered: Mass, Weight, Volume, Density, Engineering design process and Assistive Device
Student grade – 7th and 8th grade
Number and duration of class periods: 10 – 45 min (classroom) – 2 weeks home project

Research/Background

Possible Solutions:
Video: Density from Genchem and Rutgers
PowerPoint: Density from Chemistry Land
Hands on Activities: Space Grant, Widener, Rustic Girls
Apply concept into Project: Protective Helmet Project

Chosen Solution

• **Title:** Design a protective helmet for an autistic child.

* Figure 2 Clip Art

• **Objectives:** Using the Engineering Design Process students will design a protective helmet for an autistic child.

• **Constraints** (students must)**:**
✓Work in groups
✓Use the following materials: foam, cardboard, aluminum paper, plastic, glue, tape and paper.
✓Helmet must be a minimum of 2 cm thick.
✓Helmet must fit around an inflated balloon with 15 cm diameter.
✓Have prior knowledge of how to measure mass and volume, and how to calculate density.
✓Required to use the strength x density graph (below) of some materials to come up with the best solution.
✓ Helmet must cost $ 5 or less.

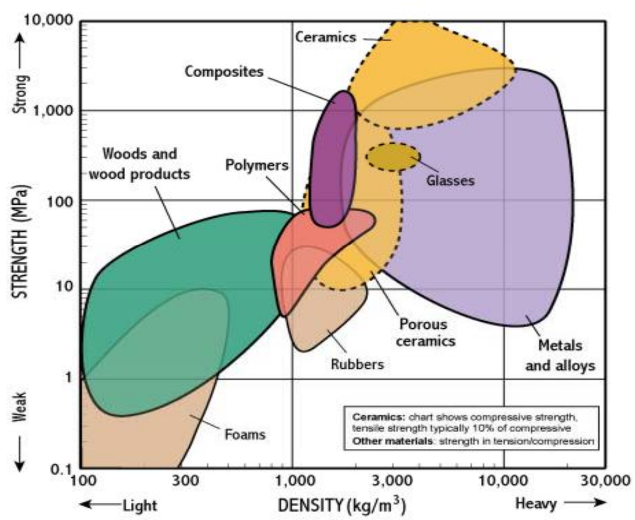


Figure 3 – Density x Strength - interactive charts

Assessment

•Based on rubric, lab work will be assessed.
•MCAS practice questions will be given.
•Based on rubrics group participation and behavior will be assessed.
•A unit test will be given.
•Based on rubrics presentations will be assessed.
•Based on rubrics the written part of the project will also be assessed.
•The prototype of the helmet will be assessed on:
✓Lowest cost
✓Best looking
✓Strongest but less dense

Conclusions and Future

My conclusions will be drawn post lesson unit be taught.
Results will follow as the lesson is presented.
Implementations are expected and will be welcomed.
This lesson unites standards and real life situation.

Acknowledgements

•Special thanks to the RET – WPI Professors and presenters.

•Adriana Hera, Christine Drew, Olyora Rezhdo, Peter Driscoll, Jeanne Hubelbank, Chris Lambert, Jianyu Liang.

•To the RET-2008 teachers and specially to my project partner Veronica Tate.

References

Massachusetts Science and technology/Engineering Curriculum Framework – October 2006
Learn NC - http://www.learnnc.org/lp/pages/3141
Strength x Density Chart
http://www-materials.eng.cam.ac.uk/mpsite/interactive_charts/strength-density/IEChart.html

Curriculum Unit and Assessment Plan

Using the density of materials to design a protective helmet

RET Project Connection

Although my assigned work in the lab was to learn LabView and design an instrument, I was exposed to various Bioengineering concepts and that led me the creation of my lesson plan. I was able to design a lesson plan incorporating Engineering Design Process and Bioengineering principles to reinforce this important and relevant topic in Physics. This unit will enhance understanding of Properties of Matter, more specifically mass, weight, volume and density. Students will then apply the knowledge acquired to design a protective helmet for an autistic child.

RET Teacher **Tanea Cezar**

School **Fuller Middle School**

Town/District **Framingham, MA**

Subject(s) taught **Math and Science**

Subjects covered/Key words

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Grades appropriate **7th and 8th Grade**

Lesson duration **2 weeks of (45 min x 10 days) lab/practice and 2 weeks home project**

Goals/Objectives of lesson

Students will be able to:

- Learn the concept of SI measurement
- Apply the concept of measurement to find mass and volume of different materials.
- Apply the concepts to find density of the materials
- Apply concepts to respond correctly to MCAS questions
- Understand the relationship between density and strength

- Use the Engineering Design Process to design a protective helmet based upon knowledge acquired from experiences
- Write a report and a draw a picture which will show and explain the reason for choosing materials for the helmet.
- Compare and contrast cost/benefits of each material chosen.

Background Information

The State of Massachusetts mandates the students to learn content within a certain frameworks. In physical science students are required to learn about properties of matter more specifically mass, volume and density. Students will benefit from this lesson by participating on several hands-on activities which will enhance the learning process. The students in science class will be challenged to design a protective helmet to an autistic child, which hurts himself by knocking his head on the wall. Over the years helmets have being made of many different materials such as Bronze, Iron, Steel, Leather, etc. Which material will be the best fit for this child? Many materials have been tested upon strength and density. Students will work on durability, strength, density and cost of the material to design and come up with the best solution.

Essential questions

How is mass related to weight?
Are mass and volume the same?
Are mass and density the same?
How is density related to mass and volume?
What are the necessary tools to measure mass and volume? How to use them?
How can density/strength values help to decide which material to use in designing a protective helmet?

Links to Frameworks and Standards – State (MA)

Content Standard A – Physical Sciences (Chemistry and Physics) Grades 6-8 - Properties of Matter Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
Differentiate between volume and mass. Define density.
Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.
Content Standard B – Technology/Engineering Grades 6-8

Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

Content Standard C – Technology/Engineering - Bioengineering Technologies Grades 6-8
Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces.

Content Standard D – Math - Measurement Grades 7-8
8.M.3 - Demonstrate an understanding of the concepts and apply formulas and procedures for determining measures, including those of area and perimeter/circumference of parallelograms, trapezoids, and circles. Given the formulas, determine the surface area and volume of rectangular prisms, cylinders, and spheres. Use technology as appropriate.

Materials Required

triple beam balance
metric ruler
overflow containers (volume of irregular objects)
fifteen dishpans
fifteen graduated cylinders
water
fifteen objects of varying mass
fifteen objects of varying volume
fifteen regular shaped objects to practice cubic volume
fifteen irregular shaped objects (use overflow container)
fifteen objects to use to determine their density

Lesson Development

Teacher will provide students pictures of a TBB (Triple Beam Balance) with labeling parts, students will practice reading the beams and adding them together. Then, to give the students practice in determining mass, place the students in groups of two, allow them to first predict the mass of fifteen different objects. Once this is complete, they should actually determine the mass of the objects using a triple beam balance, and rotating these objects until every group has measured every object. Discuss the data and any inconsistencies between their predictions and the actual data. They should discover that often the mass of an object can be deceiving and that often a small object may have a large mass or a large object may have a small mass.

Teacher will introduce different volume measuring tools such as graduated cylinder, ruler and volume formulas for different regular objects. To give the students practice in determining volume, again place the students in groups of two, and allow them to predict the volume of fifteen different objects. Teach the students the three different ways to determine the volume of objects (capacity—how much the object holds, formula method—length × width × height for cubical shapes and displacement method for objects with irregular shapes. Repeat procedures as with the mass lab and discuss any inconsistencies such as variances in volume and how size and shape can deceive perceived volume.

Students in groups of two will determine the density of various objects using the data found previously. The objects should consist of some that will float and some that will sink. Discuss how density changes according to the mass or volume of each object and explore the concept of density in relation to mass per unit volume (one gram per cubic centimeter).

Introduce the Engineering Design along with protective helmet project. Students should use the Engineering Design Process to design a protective helmet incorporating unit concepts, tie this information together into the design and creation of the protective helmet. The constraints will be also introduced to students. Such as cost and the graph: strength x density.

Divided in groups of 2 students, they will think of possible solutions for the helmet. During class time students will assess the internet for research and come up with 2 possible solutions including draft drawing and possible material to be used. Students then will decide the best solution and the best price.

Assessment

Students will be assessed during lab work and MCAS practice questions on cooperative group working skills.

At the end of this unit, the students will be given a unit test.

The students will also be graded on the project.

References

Massachusetts Science and technology/Engineering Curriculum Framework – October 2006

Learn NC - http://www.learnnc.org/lp/pages/3141

Strength x Density Chart http://www-materials.eng.cam.ac.uk/mpsite/interactive_charts/strength-density/IEChart.html

Design a Device for the Preservation and Transport Of Body Parts

Mary Fusco
PI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA

Introduction

•Industrial working environments involving handling of power equipment present a significant safety hazard.
• In the event of an accident, proper preservation, insulation and transport of severed digits crucial for successful reattachment.[1]
• Superiority of bioengineered biocomposites for medical use focal point of research performed at WPI RET.
• Biocomposites worked with in Prof. Gaudette's and Prof. Pins' labs emulate nature, are biocompatible and are designed to promote regeneration of healthy tissue.
•Nature has evolved many forms of insulation, all in the form of biocomposites.[2]
• Insulation materials that are either made from combinations of natural materials or are designed to emulate natural insulation may be superior in extreme environments to the use of one type of synthetic insulation only.

Teaching Objectives and Constraints

Problem statement:
Design a curriculum involving students in the engineering design process (EDP) to create a device, using or based upon the understanding of biocomposites for the preservation and transport of severed digits or body parts.

Objectives:
❖ Promote student engagement and improve understanding of the EDP, bioengineering, biomimicry and natural systems, using Mass. Curriculum Frameworks as a guide.
❖ Increase students' understanding of homeostasis, thermoregulation and thermal heat energy transfer in preparation for 10th-grade MCAS.
❖ Provide opportunity for students to work successfully in teams.
❖ Finish unit within designated time allotment.

Constraints:
❖ Classroom may be too small for students to move around easily and work on their design;
❖ Students may not have enough experience working in teams and become distracted and off-task as a result;
❖ Time allotment (one month) may not be adequate for completion of this project from preparation to presentation.

Topics covered: Biology, Engineering, Physics
Student grade: 9
Numbers of students: 22
Number and duration of class periods: 20 class periods / 45 minutes each

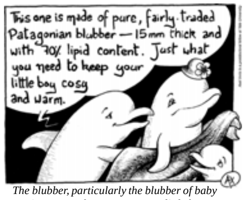
Research/Background

• Mass. Curriculum Frameworks for Grade 9 (Life Science, Engineering and Physics)[3]
• Engineering the Future [4]
• Pathfinder Regional Vocational Technical High School course description for ninth-grade Integrated Science[5]

Chosen Solution

1. **Project introduction** to the **objectives** of this module:
   At the end of this unit, students will:
   - Know and understand the steps of the EDP
   - Know the parts, functions, and processes of an animal cell;
   - Demonstrate the transfer of heat energy;
   - Apply concepts of bioengineering and biomimicry to the EDP
     ❖ A large Gantt chart showing timeline of goals to be met in this unit will be posted on the classroom wall (students will have their own copied to be kept in their binders)
2. **Pretest** using questions relating to the content covered in this unit from previous years' MCAS tests.
3. **Background:**
   Students will perform inquiry-based investigations (labs, webquests) in the following content areas
   - Cell structure, function, and processes
     ➢ Preliminary project as intro to EDP (design a model of an animal cell)
   - Homeostasis and thermoregulation
   - Heat energy transfer (conduction, convection, insulation)
   - Students will document all work in their lab notebooks
4. **The Design**
   • Students will work on their design in teams of four
   • Students will document all aspects of the design process in their engineering notebooks
   • Students will also use their Flip Video cameras to document their design process.
   • Students will use their Flip Video cameras to create a one-minute "TV" commercial advertising their finished product.

Pierre the penguin gives a whole new meaning to the term "penguin suit".[6]



The blubber, particularly the blubber of baby marine mammals, possesses very little heat conductivity.[7]

Cross-section of the fur of a fur seal, showing the double layer of fur. Cape fur seals have an amazing 50,000 hairs/cm², compared to human hair at 200 hairs/cm²![8]

Students' constraint: Their device must occupy the space inside a 2 1/4"H x 5 1/4"W x 8 1/4"L plastic pencil box.[9]

Assessments

- Post-test grade MCAS simulation test at least one full letter grade above pre-test grade (IP)*
- Completion of all tasks as per Gantt chart (TP)
- Successful completion of labs and lab reports in lab notebooks (IP)
- Successful completion of engineer's notebooks (IP)
- MS Publisher brochures on insulation materials (IP)
- Posters on thermal properties of insulation materials in nature (TP)
- Team videos of EDP (TP)
- Finished prototype of device, completed within time constraints (TP)
- One-minute TV-style video commercial of device (TP)

* IP = individual projects TP = team projects

Conclusions and Future

• This unit will be taught in October; results will be presented at November 18, 2008 WPI RET meeting.

• Students will continue with the EDP, in addition to the experimental method, throughout the remainder of the school year and into their sophomore year.

Acknowledgements

Special thanks to:

• Robin Belisle, the best partner ever;

• RET project mentors Drs. Glenn Gaudette and George Pins;

• RET principal investigators Drs. Terri Camesano and Kris Billiar

• all the generous and patient graduate and undergraduate students who helped us in the lab

• Dr. Marsha Rolle

• Pam O'Bryant, bioengineering secretary

• the teachers of this project – Tom, Cecelia, Veronica, and Tanea – for their humor and inspiration (in that order)

• Jeanne Hubelbank

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Curriculum Unit and Assessment Plan

Exploration of Concepts in Thermal Energy Transfer: Thermoregulation and the Design of a Digit Recovery and Transport Product

RET Project Connection

The work being done in Prof. Gaudette's lab is concerned with the development of strategies that would encourage an infarcted heart to heal. The materials used in this lab are derived from biological sources and are designed to minimize the formation of scar tissue, subdue adverse immune response, and allow for the proliferation of new cardiac cells. My project as a RET teacher focused on the design of a biocomposite patch of biopolymer threads and gels to be used as a patch for infarcted cardiac tissue.

As a result of my RET experience, I designed a curriculum module that would combine the bioengineering/biomimicry/ biological concepts of biocomposites and thermoregulation with the physical concepts of thermal energy transfer. Using the Engineering Design Process (EDP), students will apply the content information to the design of a product that would preserve and transport a severed digit resulting from an industrial accident. Such a product could feasibly be used in a vocational-technical school setting; the study of the design of such a device alone may conceivably serve to deter the occurrence of such an event.

RET Teacher Mary Fusco

School Pathfinder Regional Vocational Technical High School

Town/District Palmer, MA / Regional (Belchertown, Granby, Hardwick, Monson, Palmer, Ware, Warren)

Subject(s) taught Applied Physics, Integrated Science, Engineering/Technology Science

Subjects covered/Key words

physics, biology, engineering

Grades appropriate **Grade 9**

Lesson duration **Ten 45-minute class periods, with additional pre- and post-activities (preparation and presentations)**

Goals/Objectives of lesson

Students will be able to:

- Identify ways in which natural systems self-regulate to maintain homeostasis (thermoregulation in particular);
- Demonstrate how the body's ability to maintain thermoregulation is affected by exposure to extreme environments;
- Relate the biological processes of thermoregulation to the physical concepts of heat and energy transfer;
- Use the EDP to apply concepts of bioengineering and biomimicry and develop a product for the preservation and transport of severed digits resulting from industrial accidents. The device would preserve the biological integrity of the severed body part for surgical reattachment.

Background Information

The Engineering/Technology Science course is intended to provide sophomore students with an understanding of the interrelatedness of science, math, technology, and engineering. The course also prepares the students for their Engineering and Technology MCAS tests.

As Pathfinder is a vocational-technical school, all students participate in some form of industrial activity, and workplace safety is a top concern. In the unfortunate even that someone should suffer the severance of a body part, it is crucial that the body part be preserved accordingly if it is to be reattached.

Essential questions

What strategies do organisms use to maintain homeostasis and thermoregulation under extreme conditions?
What are the physics involved in the transfer of heat energy?
How are the physics of thermal energy related to thermoregulation in animals?
How can we use the EDP to design a medical device that can be used in an industrial setting?

Links to Frameworks and Standards – Massachusetts Curriculum Frameworks

I. Content Standards
Biology

4.8 Recognize that the body’s systems interact to maintain homeostasis. Describe the basic function of a physiological feedback loop.

Introductory Physics

3. Heat and Heat Transfer

Central Concept: Heat is energy that is transferred by the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.

3.1 Explain how heat energy is transferred by convection, conduction, and radiation.

3.2 Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.

II. Scientific Inquiry Skills Standards

SIS1. Make observations, raise questions, and formulate hypotheses.
SIS2. Design and conduct scientific investigations.
SIS3. Analyze and interpret results of scientific investigations.
SIS4. Communicate and apply the results of scientific investigations.

III. Mathematical Skills

- Construct and use tables and graphs to interpret data sets.
- Measure with accuracy and precision (e.g., length, volume, mass, temperature, time)
- Use common prefixes such as *milli-, centi-,* and *kilo*-.
- Use appropriate metric/standard international (SI) units of measurement for mass (kg); length (m); and time (s).
- Use the Celsius scale.

Technology/Engineering

I. Content Standards

1. Engineering Design

Central Concepts: Engineering design involves practical problem solving, research, development, and invention/innovation, and requires designing, drawing, building, testing, and redesigning. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge.

1.1 Identify and explain the steps of the engineering design process: identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct prototypes and/or models, test and evaluate, communicate the solutions, and redesign.
1.2 Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify examples of technologies, objects, and processes that have been modified to advance society, and explain why and how they were modified.
1.3 Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques.
1.4 Interpret and apply scale and proportion to orthographic projections and pictorial drawings (e.g., ¼" = 1'0", 1 cm = 1 m).
1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models.

2. Construction Technologies
Central Concepts: The construction process is a series of actions taken to build a structure, including preparing a site, setting a foundation, erecting a structure, installing utilities, and finishing a site. Various materials, processes, and systems are used to build structures. Students should demonstrate and apply the concepts of construction technology through building and constructing either full-size models or scale models using various materials commonly used in construction. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge in construction technology.
2.1 Identify and explain the engineering properties of materials used in structures (e.g., elasticity, plasticity, R value, density, strength).

4. Energy and Power Technologies—Thermal Systems
Central Concepts: Thermal systems involve transfer of energy through conduction, convection, and radiation, and are used to control the environment. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge in a thermal system.
4.1 Differentiate among conduction, convection, and radiation in a thermal system (e.g., heating and cooling a house, cooking).

Materials Required

Teacher provided:

- Sample design model of EDP

- Plastic pencil boxes
- Insulation materials (fiberglass insulation batt, wool, feathers, foam, neoprene, foam insulation, packing peanuts, shredded paper, etc.)
- All lab materials required for the labs featured in this unit
- Isometric engineering paper

Student provided:

- Other insulation materials
- 1.5” 3-ring binder
- Spiral-bound notebook for Project Journal (which also serves as a lab notebook)
- Engineer’s notebook
- Page dividers

Lesson Development

Lead up:

- Opening exercise: Watch the video: “Pierre the Penguin Gets a New Suit”
- Students brainstorm on ways that Nature has for keeping an organism warm. Create concept map as whole class on poster paper.
- Using a microscope, students will compare feathers with Velcro, and then provide a written description of how Velcro and feathers have similar functions, and relate those functions to the insulating properties of feathers.
- Students will examine fur and wool under a microscope. Students will then read about the insulating properties of these materials as well as those of blubber, and work in teams of two to create posters comparing the insulating properties of each of these materials.
- Students will design experiments testing and comparing the insulating properties of feathers, fur, blubber, and wool. Students report their findings in the form of a videotaped experiment.

<u>Design a Product for the Preservation and Transport of Severed Digits</u>

Define the Problem: (this will be student-generated)

Proper preservation and transport of severed digits resulting from industrial accidents are crucial for successful reattachment. In the event of a crisis, a device designed expressly for this purpose would be an invaluable addition to the workplace medicine cabinet.

Research the Problem:
Students will research actual cases on the internet of accidents involving the severance, preservation, transport, and reattachment of severed digits.

Develop Possible Solutions:
Students work in teams to brainstorm for possible solutions, using natural materials for insulation or ideas based on materials used in nature for insulation purposes.
Rule for brainstorming: Anything goes; no critiques!

Choose the best solution:
Students present poster presentations of their best solutions to the rest of the class.
Comments? No comments? Let students decide.

Create a prototype:
Students create their prototypes from pencil boxes and materials of their own choosing (insulation materials modeled after biocomposites, such as down and pin feathers, different layers of fur used for insulation in animals, etc).

Test and evaluate:
Students test prototypes.
NOTE: Assessments at this stage will be based on students' filming of these processes (Create a Prototype + Test and Evaluate).

Communication:
Students communicate their findings via presentations of their films (no more than 15 minutes total presentation time / team).

Redesign:

- Students receive feedback from rest of class.
- Based upon feedback from teacher and students and testing, teams will redesign their projects.

Assessment

- Students create and film a commercial selling their finished designed product (no more than 2 minutes)
- Written test based on questions from previous years' MCAS tests

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Saving Amputated Digits
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PERFORMING A MEDICAL MIRACLE WITH MULTIDISCIPLINARY SURGERY:
Making Surgical History and National News
http://www.stonybrookphysicians.com/news/performing_a_medical_miracle_with_multidisciplinary_surgery:_making_surgical_history_and_national_news_58.asp

Trauma nursing: Amputation
http://rn.modernmedicine.com/rnweb/article/articleDetail.jsp?id=103342

Main title: Design a Method for Unclogging a Blocked Artery
Subtitle: The Cardiovascular System

Cecelia Gray
WPI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA

Introduction

Educational research show that K-12 teachers and students generally have a poor understanding of what engineers do ([1]Cunningham et al. 2005; [2]Cunningham and Knight 2004). The data has found that the public believes engineers are not engaged with societal and community concerns as scientists or as likely to play a role in saving lives ([3]Harris Interactive 2006).

Dr. Marsha Rolle and Dr. Kristen Billiar's biomedical engineering labs are investigating the possibility of "tissue engineering" small diameter grafts to provide a vessel substitute that incorporates living cells and thus can actively change and adapt to a patient's particular needs similar to a healthy vessel.

Research has shown by the age of 12, an estimated 70% of children have developed the beginning stages of hardening of the arteries. This module will focus on cardiovascular health and the biomedical engineers essential contributions in the health field.

Teaching Objectives and Constraints

Problem Statement:
Society is increasingly dependent on engineering knowledge; unfortunately, middle school students are not exposed to the many career opportunities, or the positive impact engineers have on society.
Topics covered: Science, Math, and Engineering
Student grade: 6
Numbers of students: 24

Objectives:
- Students will apply the engineering design process to a biomedical problem or need that needs to be solved.
- Students will be able to define the major functions of the cardiovascular system.
- Students will identify and explain the engineering design process.
- Students will understand what engineering is and learn about what engineers produce.

Research/Background

Possible Solutions:
1. Students research an engineering-related job on the classroom computers. Then do a presentation on it.
2. Students will design a device that will assist a person with a disability
3. Collaborate with colleagues to plan an "engineering night."
4. Students will be engineers to assist a team of cardiologist to improve the method for unclogging a blocked artery.
5. Research how the problem could be solved.
   - www.teachengineering.org
   - www.school.discoveryeducation.com
   - www.engineeringyourlife.org

Chosen Solution

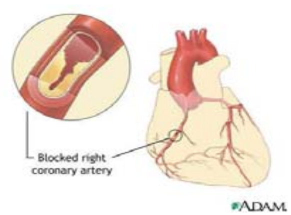
Final Selection:
Engineering a method for unclogging a blocked artery. This meets my objectives, and constraints for this module.

You are part of a group of engineers who have been asked by your clients (cardiologist) to design a method for unclogging a blocked artery. Your team will measure the flow rate of your arteries before and after your design to see if it has improved.

Objectives
- Cooperative groups of three will design a method for unclogging a blocked artery.
- Students will utilize the engineering design process to solve the problem.
- Students will measure the flow rate before and after to see if their design was successful.

Constraints
- Minimally invasive (blood vessel can not be cut completely)
- Can't change opening of artery
- Must only use materials provided in class
- Limited budget

Materials
- Tubing (varied lengths and diameter)
- Electrical tape
- Water
- Wire
- Clay
- Classroom computers (for research)



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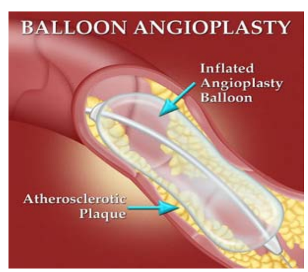

Assessment

Assessment will be ongoing and include the following:

Assessment of designs
- Prototype
- Increase in flow rate

Assessment of student learning
- Engineering Design Sheets
- presentations

Conclusions and Future

- Lessons will be taught the first term.
- Results will be reported after implementation
- Attend call back session in the fall.
- Revisions will be made as assessment dictates.

Acknowledgements

Special thanks to Alex Christakis, Dr. Marsha Rolle, and Dr. Kristen Billiar .

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Images
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Curriculum Unit and Assessment Plan

Design a Method for Unclogging a Blocked Artery

RET Project Connection

Professors Marsha Rolle and Kristen Billiar's biomedical engineering labs are investigating the possibility of "tissue engineering" small diameter grafts to provide a vessel substitute that incorporates living cells and thus can actively change and adapt to a patient's particular needs similar to a healthy blood vessel. My role with a colleague, Tom Oliva, was to design a device and method that would test the mechanical properties of tissue engineered vascular grafts. This project has greatly enhanced my content knowledge and lab experience in the biomedical engineering field.

As a result of my experience at WPI's Gateway, I have established some major goals for my classroom:

- to motivate students and give them a deeper understanding of what engineers do
- to teach the engineering design process as stated in the Massachusetts State Frameworks and the Worcester Public Schools benchmarks
- to apply the engineering design process to the biomedical/bioengineering field to solve a particular need or problem

RET Teacher Cecelia Gray

School Midland Street School

Town/District Worcester Public Schools

Subject(s) taught General Science/ Engineering/Technology; Social Studies; Math; and English Language Arts (ELA)

Subjects covered/Key words

Life science, technology, engineering, math

Grades appropriate **6**

Lesson duration **Ten weeks with four forty minute periods**

Goals/Objectives of lesson

- Students will be able to utilize the design process in order to solve a biomedical/bioengineering problem they are faced with.
- Students will measure flow rate.
- Students will explain the function of the circulatory system.
- Sub-objectives:
    - Students will identify the differences between capillaries, veins, and arteries.
    - Students will explain how engineering contributes to solving problems in the body.
    - Students will identify the primary controllable and uncontrollable factors that would put them at greater risk for developing heart disease.
    - Students will demonstrate how good cardiovascular and general health can be affected by lifestyle choices.

Background Information

The current 6th grade textbook is “Destinations in Science”. It is a general science book that is broken up into 6 units: Classification, Cells and Heredity, Control Systems, Space Science, Earth Science, and Energy Resources. Unfortunately, it does not give students a strong background in engineering and the various engineering fields. The goal of this module is to enrich the current 6th grade curriculum, and give students a strong background in engineering. Finally this module gives students the opportunity to incorporate a biomedical design component.

Essential questions

What is engineering?
What do engineers do?
What around you in life involves engineers?
What is the difference between engineering and science?
How do engineers solve problems?
What are the steps of the design process?
What are the functions of the circulatory system that keeps you alive?
Explain how oxygen and nutrients get delivered to the body’s cells?

Links to Frameworks and Standards

Explain the organization of living things.
Identify structures such as cells, tissues, organs, and systems.
STANDARD 5
Life Science
Gr. 6-8
WPS BENCHMARKS (06.SC.LS.08)
Explain the relationships of cells, tissues, organs, and systems.
STANDARD 5
Life Science
Gr. 6 -8
WPS BENCHMARKS (06.SC.LS.08)
Identify the major components and functions of the following human body system: circulation.
STANDARD G
Life Science
Gr. 6-8
WPS (06.SC.LS.10)
Explain how different body systems identify the major components and functions of the following human body system: circulatory system.
STANDARD G
Life Science
Gr. 6-8
WPS BENCHMARKS (06.SC.LS.10)

Engineering Design Process
STANDARD 2
Gr. 6-8
Technology/Engineering
WPS BENCHMARKS (06.SC.TE.01-08)

Materials Required

See below

Lesson Development

Hand out Pre-test to students, and display the Engineering Design Process poster in the classroom. The Pre-test is intended to act as a reference point to determine how effective the engineering curriculum has been. Administer the same test at the end of the school year as a Post-test and compare the two.

Procedure:

Allow 15 minutes for students to take the pre-test.

- Cooperative groups of 2-3 students will brainstorm the definitions of the following terms: engineering, science, and biomedical engineering. Then students will list the things engineers do. Students record their answers on chart paper and then share with the class.
- Review with students the various types of engineers and what they do.
- Students will use the classroom computers to research one engineer related career for a presentation that may have sparked their interest. They will incorporate the following questions into their presentation:

General Questions

1. Briefly describe the purpose of this job.
2. What are some specific tasks?
3. What kind of education and experience is required?
4. Describe the kinds of places that people with this job might work. (For example, in a lab, outside, or in an office?)
5. In what types of companies do people with this job work?

Personal Questions

1. What would you like about this job? What wouldn't you like about this job?
2. What would be the most challenging thing?
3. Do you think this job is a good fit for you? Why or why not?

As homework, students will create a poster entitled "If I were a …" about the profession they chose. The poster should include answers to the questions above.

Students will present their posters to the class, making sure they discuss the jobs, particularly something that most surprised them about these careers.

Examples of Engineering Disciplines
Aeronautical Engineering – design of machines that fly such as air planes & rockets.
Biomedical Engineering – design of medical devices and medicines.
Chemical Engineering - design of chemicals and chemical products through chemical processes.
Civil Engineering – design of roads, bridges, & dams using soil, rocks & concrete.
Computer Engineering – design of computers and how they are connected.
Electrical Engineering – design of electrical circuits found in radios, televisions & computers.
Manufacturing Engineering – design of factory floor layouts & assembly lines containing various machining tools.
Mechanical Engineering – design of machines & devices with moving parts such as gears.
Structural Engineering – design of buildings such as bridges & skyscrapers with beams & supports

- Students will watch a video clip of an engineer and learn about her life. Jessica Miller's story www.engineeringyourlife.org/cms/6167/6194.aspx?eylprofile=Story
- Students will listen to and participate in a power point presentation of the heart. This will take place over several weeks.
- Students will design a method for unclogging a blocked artery using the engineering design process.

Cardio Doc/Engineering Team:
Research has shown that by the age of 12, an estimated 70% of children have developed the beginning stages of hardening of the arteries.
The clogged artery will be prepared ahead of time by the teacher to simulate an atherosclerotic artery. The arteries (tubes) will be sticking out of the bottom of the bucket. Students will time the flow using stopwatches or the classroom

clock. Buckets will also be provided to catch the flow. Students will be given a range of tubing lengths and diameters to use. Students can "bypass" the clog with another piece of tubing or clean it out like angioplasty.
Students are part of a group of engineers who have been asked by their clients (cardiologist) to design a method for unclogging a blocked artery. The team must measure the flow rate of the arteries before and after the design to see if it has improved.

Materials List:

- Scissors
- Waterproof tape (Such as duct tape or electrical tape)
- Flexible plastic tubing (2-2 in. in diameter and 4 in. length/group)
- Flexible plastic tubing (Varied length and diameter)
- Wire
- Water
- Clay
- Beaker
- Bucket or pan

Constraints:

- Minimally invasive (Blood vessels cannot be cut completely)
- Can't change opening of artery
- Must only use materials provided in class

Limited budget

Assessment

A project based assessment will be completed.

References

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Design of an Assistive Device to Increase the Functionality of a Person With a Disability

Thomas Oliva
WPI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA

Introduction

Engineering programs emphasize Engineering Design Process
- Design Process is an essential component to problem solving
- Provides an intelligent, iterative system for working through the development of a solution to a client's needs

Biomedical Engineering combines the fields of engineering, biology and medicine
- Improves human health through cross-disciplinary activities
- Integrates the engineering sciences with the biomedical sciences and clinical practice.[1]

Teaching Objectives and Constraints

Objective
Develop a lesson to develop understanding of the Engineering Design Process that uses Biomedical Engineering

Constraints
- Must be completed in four weeks.
- Must be completed with resources in the school Technology Lab.
- Must be designed and created in work groups (design teams).

Topics covered	Engineering Design, Math
Grade level	Grade 7 or 8
Numbers of students	20-25
Lesson duration	20 class periods, 50 minutes

Research/Background

Technology-Related Assistance for Individual with Disabilities Act
- 1998 (PL 100-407)-first legal definition of assistive technology devices
- An assistive technology device defined:
  - "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities."[2]

Possible solutions to this design problem are:
- Design a device to protect a person in wheelchair from rain
- Design a device for someone with limited grip strength to hold a cup
- Design a device that a paralyzed person can use to exercise
- Design a device for students to build or increase fine motor skills
- Design a device to help a paraplegic person reach an object

Chosen Solution

Problem Statement
Design a device that will help students improve their fine motor skills.


3

Objectives
- To increase understanding of the Engineering Design Process
- To use the Engineering Design Process to solve a design problem
- To work cooperatively as a design team to solve a problem.
- To increase understanding of the need and importance of assistive devices

Constraints
- Must weigh less than 5 lbs.
- Must be easy to use
- Must be durable
- Most cost less than $20 to make
- Must be one piece when finished with no moving parts
- Must reflect a specific student's (client's) needs.
- Must be completed with resources in the school Technology Lab
- Student must interview their clients

Reasons for Selection
- Fits into the constraints of cost and time
- More practical- "clients" are students in the school
- Design projects do not end at the prototype stage but result in a deliverable product students will actually use


4

Benefits of Selection-
- Design students can interview their clients each day
- Clients can test the designs soon after they are made thereby making it easier to make revisions to design
- Clients can benefit developmentally from a design project
- Design students can directly see the value of the design and the value of an assistive device

Assessment

Design Students
- A rubric will be developed to assess the design students' degree of completion of design tasks
- A pre-test and post-test will be given to determine students knowledge of the design process
- Students will complete a reflective Engineering Design worksheet on which they may out the process of their work on the project
- A survey will also be given to students to assess their knowledge and awareness of assistive devices. The survey will be administered before and after the module.

Design Project
- The effectiveness of the design project as an assistive device will be assessed by a pre-test and post test that will be given to the clients

Conclusions and Future

- Lessons to be taught during the first quarter of the school year
- Follow up to take place in November, 2008
- Results available after implementation
- Revisions to be made to project to refine objectives

Acknowledgements

- Dr. Terri Camesano and Dr. Kristen Billiar for their design of effective teacher training program that increased our knowledge of Biomedical Engineering and the Engineering Design Process.
- Jeanne Hubblebank for facilitating productive sessions pertaining to curriculum and assessment

References

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2. Americans with Disabilities Act
3. http://www.coe.iup.edu/njyost/DI/Fine_Motor/austinlacing.jpg
4. http://www.montessoriforeveryone.com/blog/uploaded_images/bigstockphoto_Stitching_A_Star_1504308-777819.jpg

Curriculum Unit and Assessment Plan

Design of a Device to Build Fine Motor Skills

RET Project Connection

Biomedical Engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice. Source: The Whitaker Foundation

At Worcester Polytechnic Institute, Dr. Kristen Billiar and Dr. Marsha Rolle seek to solve problems within the scope of engineering new tissues for various uses in the human body.

Within the confines of the Biomedical Engineering department, there is a high priority placed on the Engineering Design Process. A focus on this essential component helps to ensure success. While in engineering success doesn't typically happen on a first attempt, the design process provides an intelligent, iterative system for working through the development of a solution to a client's needs.

RET Teacher — **Thomas Oliva**

School — **Forest Grove Middle School**

Town/District — **Worcester Public Schools, Worcester, MA**

Subject(s) taught — **Technology and Engineering**

Subjects covered/Key words

engineering design, sketching, safety, tools, math

Grades appropriate — **Grade 7 or 8**

Lesson duration — **4 weeks**

Goals/Objectives of lesson

Goals:

- To increase student understanding of the Engineering Design Process.
- To increase student understanding of Bioengineering.
- To increase student understanding of the need and importance of assistive devices.

Students will be able to:

- List the steps of the Engineering Design Process
- Define Bioengineering
- Design an assistive device

Background Information

In grades 6–8, students pursue engineering questions and technological solutions that emphasize research and problem solving. They identify and understand the five elements of a technology system (goal, inputs, processes, outputs, and feedback). They acquire basic safety skills in the use of hand tools, power tools, and machines.

They achieve a more advanced level of skill in engineering design by learning to conceptualize a problem, design prototypes in three dimensions, and use hand and power tools to construct their prototypes, test their prototypes, and make modifications as necessary. The culmination of the engineering design experience is the development and delivery of an engineering presentation. Source: Massachusetts State Department of Education

Essential questions

What does it mean to design something?
What is the Engineering Design Process?
Why do things need to be designed?
What role does the client play in engineering design?
What importance do assistive devices have to humans?

Links to Frameworks and Standards – National

Content Standard E
As a result of activities in grades 5-8, all students should develop:

ABILITIES OF TECHNOLOGICAL DESIGN
Identify appropriate problems for technological design
Design a solution or product

Implement a proposed design
Evaluate completed technological designs or products
Communicate the process of technological design

Links to Frameworks and Standards – State (MA)

1. MATERIALS, TOOLS AND MACHINES
1.1 Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility).
1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an engineering design.

2. ENGINEERING DESIGN
2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.
2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.
2.3 Describe and explain the purpose of a given prototype.

4. MANUFACTURING TECHNOLOGIES
4.1 Describe and explain the manufacturing systems of custom and mass production.

7. BIOENGINEERING TECHNOLOGIES
7.1 Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces.

Links to Frameworks and Standards – Local

Worcester Public Schools

07.SC.TE.02- Identify and explain the appropriate tools, machines, and electronic devices (drawing tools, computer aided design, and cameras) used to produce and/or reproduce design solutions (engineering drawings, prototypes, and reports).
07.SC.TE.05 Describe and explain the manufacturing systems of custom and mass production. Explain and give examples of the impacts of interchangeable parts, components of mass-produced products, and the use of automation, e.g., robotics.
07.SC.TE.07 Explain basic processes in manufacturing systems, (cutting, shaping, assembling, joining, finishing, quality control, and safety).
08.SC.TE.07- Explain examples of adaptive or assistive devices (prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces).

Materials Required

pencils, rulers, graph paper,
materials for building (wood, plastic, cardboard)
materials for fastening (glue, nails, screws)
tools for cutting, assembling, finishing
computers with Internet access

Lesson Development

For purposes of this curriculum project, the students making the project will be referred to as the “design” students. The students for whom the devices are being made will be referred to as the “client” students or “clients”.

Week 1

- Introduce the Engineering Design Process (EDP).
- Begin with graphic and explanation of EDP.
- Start with developing a problem (client) statement (Step 1).
- Continue with researching the problem (Step 2). Introduce fine motor skills and assistive devices.

Week 2

- Develop possible solutions to problem (Step 3).
- Develop objectives for possible solution

- Introduce Multiview and Isometric drawing
- Students will make rough sketches of designs for their devices
- Select the best solution based on stated objectives (Step 4).

Week 3

- Introduction to lab area- coverage of layout, tools, safety
- Begin developing prototype for device design (Step 5).
- Test prototype with clients (Step 6).

Week 4

- Develop solution presentation (Step 7).
- Make necessary modifications (Step 8).
- Finish design and fabrication of device

Assessment

A rubric will be developed to assess this design project. The rubric will assess the degree to which the design students completed assigned tasks in each step of the Engineering Design Process for the project inclusive of the final design presentation.

References

Massachusetts State Department of Education
http://www.doe.mass.edu/frameworks/scitech/1006.pdf
National Science Foundation
http://www.nap.edu/html/nses/6d.html#st
Worcester Public Schools
http://www.wpsweb.com/benchmark/sec/scitech.pdf

Adaptive and Assistive Devices

Veronica L. Tate
WPI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA

Introduction

Using the Engineering Design process, design a curriculum unit which teach Bioengineering technologies in a manner that is interesting, motivating and effective. Including a inquiry-based pedagogy and group activities, encouraging self-discovery.


Figure 1 – clip art


Figure 2 – Clip art

Teaching Objectives and Constraints

Objectives;
Using the Engineering design process (T.E. 2.1), teach T.E. 7.1
7.1 Explain examples of adaptive or assistive device, e.g. prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces
Constraints:
Time – Make time to teach technology
Lack of materials – Be sure to have materials available.
Lack of tested lesson plans
Cost-effective – Lessons need to be reproduced without costing too much money
Differentiated Learning – All proposals should affect different learners
Topic Covered: Engineering Design Process; Bioengineering Medical Technologies;
Student Grade: 7th and 8th
Number and duration of class periods: five(7) – 45 minute

Research/Background

Researched yielded five possible solutions:
Solution 1: Various Lesson plans using ROBOLAB and LEGO
Cost-prohibitive! Due to high cost, these activities will not be used
Solution 2: DESIGN A PARAPLEGIC EQUESTRIAN SADDLE
This solution was written for grades 9-12. The vocabulary is a little beyond Middle School
Solution 3: DESIGN A RUNNING SHOE FOR A TRIATHLETE
This solution was written for grades 9-12. The vocabulary is a little beyond Middle School
Solution 4: Build Your Own Robot Arm
Solution is age appropriate and can be used with Middle School Students. Very limited modifications are needed. It can be inexpensively created. However, I do not know if my familiarity with electrical and electronic concepts might hinder student's progress.
Solution 5: Adaptive device Design: Best Solution:
Solution is age and grade level appropriate. Teaching the lesson does not depend upon the teacher's understanding of electrical or electrons concepts. No major modification to the lesson is needed. It is inexpensive to do the lesson. Solution is age appropriate. Teaching the lesson does not depend upon the teacher's understanding of electrical or electrons concepts. No major modification to the lesson is needed. It is inexpensive to do the lesson.

Chosen Solution

Title: Assistive and Adaptive Device Design
Objective: Create an Assistive Can Opener for a disable person

Problem:
A Soldier comes back from Iraq with a missing right arm and his middle two fingers and thumb are missing from his left hand. He comes to your company with a request an assistive device to open a can of soda. Using the design process, students will create the device to assist the soldier with opening the soda can.

Constraints:

Must watch how to open a can:
http://www.kazivu.com/innovation/648/Opening_a_Pop_Can
Must view a can opener bottle-opener for arthritic people:
http://www.opensesameusa.com/
Device has to be low-tech
Device can not be purchased
Materials will be provided by teacher

Low -Tech and Middle and Elementary
Assistive and Adaptive devices

Figures from At.ptt

High Tech Assistive and Adaptive Devices

Figures from At.ptt

Assessment

Pre-test: A pre-lesson set of questions will be given prior to start of any new concepts, to determine what students know.
Brain warmers: A question students are given 5-7 minutes to complete answers can be either written or verbal to assess students understanding of the topics. This done is at the beginning of the class.
Exit Slips: A question students are given 5-7 minutes to answer prior to leaving the class to assess student's understanding of the daily lessons
Post-test: After lesson an assessment will be given to determine what students have learned. This assessment could be in the formative or summative.
Student Lesson Evaluation:
Product/no product: Usability, creativity, and purchasable
Device will be assessed by soldier (teacher or other students from other groups with right arm behind back and fingers taped down). The devices will be given points on creativity, usable, and whether or not client would purchase the product. Device with the highest points will be given a prize.

Conclusions and Futures

Engineer Design Process is an excellent tool for teaching student. They learn to design and create devices.
The Process will be used within the classroom and in the after school program

Future plans:
Creation of the lessons for Bioengineered products
Using the Engineering Design process
Test lesson plans using LabView and Veriner hardware :
Heart Rate and Body Position
Graphing your motion.

Acknowledgements

All the professors and presenters in the RET program
My partner Tanea Czaer
LabView instructor: Adriana Ahera
Librarian: Christine Drew
Mentors: Chris Lambert and Jianyu Liang
Graduate Students from both labs

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http://www.bu.edu/gk12/alex/bioengineering_teacher.pdf
http://www.techboston.org/itest/plans.html
http://www.lessonplanet.com/
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www.uwlax.edu/DRS/PPpresentations/AT.PPT
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Curriculum Unit and Assessment Plan

Assistive and Adaptive Devices

RET Project Connection

Our client's research focused on controlling nanostructure Morphology by template wetting using multilayer polymer thin film. Temperature optimization is very important, since the surface tension of polymer melt is strongly depended upon temperature. As instrumentation required for process control such as temperature probes are costly. This project investigated how LabView may be used to build laboratory instrumentation inexpensively. LabView is a high level programming language that was designed to facilitate the interfacing of computers to instrumentation. Today, LabView may be used to not only control and instrument but also create an instrument at a fraction of the costly of filtering and prepare experimental reports.

In the project, we were to learn to program in LabView within the first few days.

Although my assigned work in the lab comprised of learning LabView and designing an instrument, I gained content information regarding Assistive and Adaptive devices and Assistive and Adaptive products during presentations and lunchtime seminars. Additionally during my research for LabView tutorial, I discovered Vernier Software & Technology produces hardware and software for data collection in high school, middle school, and college science.

This lesson plan focuses on Assistive and Adaptive Devices. Lessons focusing on Assistive and Adaptive products and LabView will be created in the very near future. All lesson plans were or will be created using the Engineering Design Process.

RET Teacher Veronica L. Tate

School Worcester East Middle School

Town/District Worcester Public Schools, MA

Subject(s) taught General Science

Subjects covered/Key words

technology & engineering

Grades appropriate **7 & 8th grade**

Lesson duration **Five- 45 minutes periods**

Goals/Objectives of lesson

Objectives: Using the Engineering design process (T.E. 2.1), teach T.E. 7.1

7.1 Explain examples of adaptive or assistive device, e.g. prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces

Sub-objectives:

Students will practice writing to improve skills as directed by writing through curriculum guidelines.

Students will learn appropriate vocabulary associated with bioengineering

Students might be inspired to learn more about bioengineering

Students will use the steps of the engineering design process, i.e., identify the need or problem, research the , develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

Background Information

Lesson Focus

Lesson focuses on the engineering of adaptive or assistive devices, such as prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, or braces.

Lesson Synopsis

The Adaptive Device Design activity explores the concept of how engineering has made possible the development of -- and ongoing improvements to -- adaptive devices that serve to help individuals with a wide range of physical challenges adapt to the world and participate fully in society. Students learn about the engineering design process to solve problems, and work in teams to improve the design of a current or proposed adaptive device. Students start with eyeglasses, disassembling, examining component design and shape, and reassembling…then re-engineer the product seeking improvements to the current product.

Essential questions

What is an Assistive device?

List the 8 steps of the engineer design process

Define 8 steps of the engineer design process

What is bioengineering?

How is Bioengineering related to Assistive Devices?
Compare and Contrast Assistive and Adaptive devices

Links to Frameworks and Standards – State (MA)

2. Engineering Design

Central Concept: Engineering design is an iterative process that involves modeling and optimizing to develop technological solutions to problems within given constraints.

2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

7. Bioengineering Technologies

Central Concept: Bioengineering technologies explore the production of mechanical devices, products, biological substances, and organisms to improve health and/or contribute improvements to our daily lives.

7.1 Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces.

Materials Required

Student Resource Sheets
Student Assistive devices worksheets
Students' Engineering design process worksheets
One set of materials for each group of students:

One pair of sunglasses (either old or inexpensive new)
Eyeglass Repair Kit (including mini screwdriver, replacement screws, and if possible a magnifying glass

Lesson Development

Day 1:

Objective: Students will identify what are adaptive devices. Students will simulate what it is like to have a disability.

Activities:

Part1: Student will be given Pre-test.

Part 2: Students will be told that they will be asked to do a task and timed. The person who completes the task the fastest will be allowed to get a prize. All students will be given a nut and a bolt. Prior to starting the timer, ½ of the students will be given large garden gloves. This will simulate having a disability.

Part 3: students will be asked to come up with ways that they may simulate a disability

Part 4: Students will view AT.PTT (a power point presentation on Assistive technology)

Part 5: Students will complete Student worksheet identifying Adaptive Devices

Day 2:

Objective: Students will review the engineer design process.

Activities:

Part 1: Students will go over the steps of the design processes with the teacher.

Part 2: In groups, students will be select a design exercise provided by the teaching Based on their understanding of the design process, students will Complete the design process

Day 3:

Objective: Using the Engineering design Student will design an assistive device: This is a 3 day project which includes a research day and a redesign component. Day 1 of the project will have students doing reverse engineering.

Activities:

Part 1: In groups, Students will read resource material.

Part 2: Using Adaptive Device worksheet: Component parts Student will disassemble and reassemble unusable sunglasses

Part 3: If there is time, Using Adaptive Device Design Worksheet and the engineer design work sheets start your groups' design project.

Day 4:

Objective: Using the Engineering Design process Students will design an assistive device:

Activities: Students will meet in the computer lab to research and continue working on their project

Day 5:

Objective: Students will demonstrate their ability to list, define and use the engineering design process. Students will present their assistive device product to the class

Activities:

Part 1: Students will complete post-test (same five questions)
Part 2: Students will present their products
Part 3: Students will evaluate this week's lesson: What did you learn? What was good about lesson?

Assessment

Pre-test: A pre-lesson set of questions will be given prior to start of any new concepts, to determine what students know.
Brain warmers: A question students are given 5-7 minutes to complete answers can be either written or verbal to assess students understanding of the topics. This done is at the beginning of the class.
Exit Slips: A question students are given 5-7 minutes to answer prior to leaving the class to assess student's understanding of the daily lessons
Post-test: After lesson an assessment will be given to determine what students have learned. This assessment could be in the formative or summative.
Student Lesson Evaluation:
Product/no product: Production or no production of the device will also be used as a form of measurement.

References

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http://www.swe.org/iac/lp/index.html
http://www.rehabtool.com/at.html
www.uwlax.edu/DRS/PPpresentations/AT.PPT
http://www.redcross.org.uk/